CHAPTER 7 GROUND WATER PATHWAY

LIKELIHOOD OF RELEASE

Observed Release or Potential to Release Containment Net Precipitation Depth to Aquifer Travel Time

WASTE CHARACTERISTICS

Toxicity/Mobility
Hazardous Waste
Quantity

TARGETS

Nearest Well
Population
Resources
Wellhead Protection
Area

SECTION 7.1 DETERMINING AQUIFER BOUNDARIES AND NUMBER OF AQUIFERS



In the HRS, a ground water pathway score is developed for each aquifer that underlies either sources at the site or contamination that is attributable to the site. In addition, aquifers that are in direct contact with or interconnected with aquifers that underlie sources at the site may be included in the evaluation. The first step in scoring the ground water pathway, therefore, is to identify the geologic materials that comprise aquifers that directly underlie sources at the site. This section provides guidance on information sources that can be used to identify such geologic materials.

Once the geologic materials under sources at the site are identified, guidance is provided on how to carry out these next steps:

- Identify boundaries for each aquifer that underlies sources at the site by combining appropriate geologic materials;
- Determine if any discontinuities completely transect such aquifers within the 4-mile TDL and disregard portions of the aquifers on the far side of the discontinuity from evaluation;
- Examine possible interconnections between aquifers that are separated by apparent aquifer boundaries; and
- Combine aquifers interconnected with aquifers that underlie sources at the site into a single hydrologic unit, and determine how many hydrologic units need to be evaluated for the ground water pathway.

Guidance in this section focuses on the major issues typically arising in aquifer evaluations. To the maximum extent possible, this information is presented in a form that does not require extensive expertise in the principles of geology. However, expertise in geology is often required to compile and analyze the data used to define aquifers for HRS purposes. Further, while this guidance is intended to be applicable across a wide range of sites, professional judgment will be needed to apply the evaluation criteria to site-specific circumstances.

In general, aquifer boundaries occur between two different geologic materials, only one of which is used as an aquifer (or both are used as aquifers and one has a significantly lower hydraulic conductivity). However, there can be geologic features that occur within the same geologic materials and that present a barrier to ground water flow and hazardous substance transfer. Such features are referred to as aquifer discontinuities.

The presence of aquifer interconnections is evaluated only when one or more aquifer boundaries (including discontinuities) are present within 2 miles of sources at the site (or within areas underlying ground water contamination attributable to the site). For HRS purposes, aquifers can be combined into a single hydrologic unit if they are shown to be interconnected.

A precise definition of aquifers requires comprehensive scientific data that may be beyond the scope of an SI. Further, in complex geologic settings, precise definition of aquifers may be beyond

current scientific understanding. Therefore, the guidance in this section describes a level of investigation associated with gathering the necessary information on aquifers and their boundaries to support HRS scoring of a site that is consistent with the level of investigation that has been employed successfully for purposes of listing sites on the NPL..

RELEVANT HRS SECTIONS

Section 3.0.1.1 Ground water target distance limit

Section 3.0.1.2 Aquifer boundaries
Section 3.0.1.2.1 Aquifer interconnections
Section 3.0.1.2.2 Aquifer discontinuities

DEFINITIONS

Aquifer: One or more strata of rock or sediment that is saturated and sufficiently permeable to yield economically significant quantities of water to wells or springs. An aquifer includes any geologic material that is currently used or could be used as a source of water (for drinking or other purposes) within the TDL.

Aquifer Boundary: A physical barrier to ground water flow identified as the contact between geologic materials defined as an aquifer and materials defined as non-aquifer (or as an aquifer but with a significantly lower hydraulic conductivity). Where aquifer interconnections are documented, aquifer boundaries are expanded to encompass the interconnected aquifers.

Aquifer Discontinuities: Geologic and hydrologic features or structures that entirely transect an aquifer (or multiple aquifers, if interconnected) and that are expected to disrupt and/or prevent the flow of ground water and hazardous substances across the feature or structure. Aquifer discontinuities are a type of aquifer boundary.

Aquifer Interconnections: Subsurface conditions that allow two or more aquifers separated by aquifer boundaries to be combined into a single aquifer (i.e., a single hydrologic unit). Subsurface conditions must demonstrate that the aquifer boundaries separating the aquifers do not or would not impede the flow of ground water and hazardous substances between the aquifers. Aquifer interconnections are evaluated within two miles of sources at the site and in areas underlying contamination attributable to the site.

Confining Layer: A layer of low hydraulic conductivity (relative to adjacent geologic materials) that is not expected to be used as an aquifer.

Hydraulic Conductivity: The overall ability of water to flow through a geologic material, accounting for all openings in the material (e.g., between grains, through fractures, along lava tubes). For HRS purposes, the terms hydraulic conductivity and permeability are used interchangeably.

Layer of Lower Relative Hydraulic Conductivity: A geologic material with lower hydraulic conductivity than adjacent geologic materials. If used to establish aquifer boundaries, the difference in hydraulic conductivity should be at least two orders of magnitude.

Single Hydrologic Unit: The combination of geologic materials and aquifers that are determined to be within the same aquifer boundaries, including all interconnected aquifers.

Target Distance Limit (TDL) for the Ground Water Migration Pathway: The distance over which targets are evaluated. The TDL is generally a 4-mile radius from sources at the site, except:

- Include any drinking water well with an observed release attributed to the site, regardless
 of its distance from the source.
- Exclude wells completed in portions of an aquifer that are beyond an aquifer discontinuity.

Top of the Aquifer: In unconfined (water table) aquifers, the uppermost elevation of water, accounting for temporal variations, as long as the water table occurs in the materials used as an aquifer. In confined aquifers, the top of the geologic material producing water.

Well Log: A record of geologic materials with depth based on data obtained beneath a point on the land surface and representative of types, depths, and thicknesses of materials beneath that point. The data may represent visual observations, physical/chemical characterizations, and/or geophysical properties. The record also contains information on wells (drinking and monitoring), where appropriate.

IDENTIFYING AND EVALUATING AQUIFERS

To understand and describe aquifers and their boundaries for HRS purposes, the scorer must compile sufficient information to identify the types and boundaries of geologic materials that underlie sources at the site. The ultimate goal of the evaluation is to determine which drinking water wells within the 4-mile TDL are located in geologic materials that either underlie sources at the site (or contamination attributable to the site) or are interconnected with such geologic materials within 2 miles of sources at the site. The information should, at a minimum, identify:

- Types of bedrock and their boundaries (both lateral and vertical);
- Types of surficial deposits and their boundaries (both thicknesses and lateral extents);
 and
- Locations and screened depths of wells being evaluated as targets.

Scorers are faced with determining the appropriate level of investigation to define aquifers and their boundaries. Given the level of effort associated with PAs, SIs, and preparation of HRS packages, the definition of aquifers and their boundaries relies principally on existing information. This existing information may be augmented with site-specific information collected during the SI, such as through the installation of soil borings, construction of monitoring wells, sampling of monitoring or other wells, visual observations of springs or any other measurements or observations providing insight into geologic materials and aquifers.

The approach used in the HRS evaluation and scoring of aquifers is first to establish an aquifer, and then to expand its boundaries, combining it with other aquifers for HRS purposes as information arises to justify the expansion or combination. The types of data and levels of investigation used to evaluate aquifer boundaries can be divided into three categories. The first level of investigation is expected to be adequate to define aquifer boundaries at the majority of sites, The second level of investigation is expected to be needed at a small percentage of sites to refine aquifer boundary determinations. Both the first and second levels of investigation rely on existing data or that collected during the PA/SI. The third level of investigation defines activities beyond the scope of a typical PA/SI that, on a limited basis, may be performed to define aquifers for HRS purposes. Data collected to support these levels of investigation are described in more detail in *Highlights 7-1, 7-2*, and *7-3*.

HIGHLIGHT 7-1 AQUIFER DATA USED FOR FIRST LEVEL OF INVESTIGATION

Although this type of data is expected to be adequate for a majority of sites, some sites may require collection of additional data. At some sites, however, aquifer boundaries may be described when only portions of the data in this category have been collected.

- Use state, regional, or county bedrock geology maps as a starting point for identifying geologic formations and materials within the 4-mile TDL.
- Use state, regional, or county maps on surficial deposits of unconsolidated materials, overburden thickness, and depth to bedrock (if available) to augment the bedrock geology map.
- Collect scientific journals on geology or ground water resources in the area published by Federal
 agencies (at a minimum, check bibliographies of the USGS and the U.S. Department of Agriculture).
 Look for geologic descriptions, geologic maps, cross-sections of geologic formations, and ground water
 use Information.
- Collect publications, circulars, bulletins or any other reports from state agencies responsible for
 geologic or ground water resource information. The responsibility for geologic and ground water
 resource information may reside with separate state agencies; Investigate Departments of
 Environments, Departments of Natural Resources, Pollution Control Agencies, Ground Water Resource
 and/or Protection Offices, Departments of Health, and any others with possibly pertinent information,
 Look for information described above for Federal sources along with well logs for drinking water wells.
- Check with county and other local environmental and health officials for information on geology and ground water use, including well logs for drinking water wells.
- Contact site personnel, area residents, local officials, and water supply companies to determine sources
 of drinking water.
- Augment data identified above with site-specific information collected during the PA/SI, including depth
 to ground water, depth of drinking water wells, geologic materials at the site, and ground water use.

The data collected above should serve in most cases to delineate geologic materials and to identify which geologic materials are being used as drinking water sources. If these data do not adequately identify aquifers, their boundaries, and ground water targets, additional data collection may be necessary.

HIGHLIGHT 7-2 AQUIFER DATA USED FOR SECOND LEVEL OF INVESTIGATION

A review of the data identified as primary usually is adequate to evaluate aquifers for HRS purposes. However, secondary data may be needed to characterize more fully the boundaries of aquifers relative to adjacent materials. Such data include:

- Existing data on aquifer testing such as pumping and slug test data
- Contaminant migration studies
- Cross-sections generated from well log data by the scorer
- Ground water data and references from other NPL sites within the 4-mile TDL (this is considered secondary information since it may only serve to identify sources of information previously undetected)

Secondary aquifer data are not necessary to define aquifers at a site. Rather, they serve to expand aquifer boundaries, as appropriate, so that the potential threat to ground water targets within the TDL is more accurately reflected. Nonetheless, secondary aquifer data should be collected and compiled if encountered during collection of primary aquifer data.

HIGHLIGHT 7-3 AQUIFER DATA USED FOR THIRD LEVEL OF INVESTIGATION

Tertiary aquifer data include those data that are determined to be absolutely critical to the scoring of a site, but are not available after the collection of primary and secondary aquifer data. Under these circumstances, the allocation of additional resources may be warranted. The decision to allocate additional resources should Incorporate a consideration of the costs of acquiring additional information. EPA is prepared to provide technical support on a case-by-case basis to assist in these decisions. Tertiary aquifer data include the following:

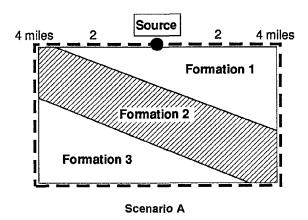
- Installation of additional monitoring wells beyond those included in an SI
- Performance of aquifer (pumping and slug) tests
- Mapping of geology in the field

It is anticipated that tertiary data will only be warranted at a limited number of sites.

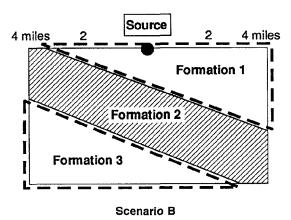
This section describes one approach for identifying and evaluating aquifers. In general, this approach is based on the fact that much of the geologic literature and information to be collected is presented and organized by geologic formations. Indeed, aquifers may be identified in the literature as corresponding to specific geologic formations. However, for HRS purposes, an aquifer may consist of multiple formations or may be limited to discrete portions of a single formation which differ from aquifer boundaries as identified in the literature. Thus, the procedures outlined below are intended to provide one possible approach for the compilation of information on geologic formations and to provide guidance on evaluating the data in order to establish aquifer boundaries for purposes of HRS scoring.

- (1) **Collect readily available information on geology.** Focus on first level data, as detailed in **Highlight 7-1**, but collect any second level data encountered. Proceed until all first level data are collected or until a person knowledgeable about scoring of aquifers for HRS purposes has determined that sufficient information is available to identify aquifers and their boundaries.
- (2) **Collect information on ground water use.** Continue to collect data until the source of drinking water can be characterized for all ground water targets being evaluated (this effort overlaps with identification of drinking water sources for the surface water pathway). Note other, non-drinking water uses for ground water within the TDL. Although specific guidance is provided in later sections on the detailed evaluation of targets (see Sections 7.4 through 7.9), it is important to remember that if no drinking water wells are located in geologic materials, it generally is not necessary to characterize these materials.
- (3) Compile and analyze data from Steps (1) and (2). Resolve any real or apparent discrepancies in the geologic or ground water use information. Where information is deemed credible, give preference to local or site-specific information over regional information. Similarly, give preference to regional information over state-wide information. The result of Step (3) should be an understanding of the geologic setting and ground water use sufficient to do the following:
 - Create a map of the geologic formations within the 4-mile TDL;
 - Construct typical cross-sections of the geologic formations in several different directions through the 4-mile TDL (the cross-sections do not necessarily have to be prepared, but the information available should be sufficient to be able to do so); and
 - Determine the geologic material being used if provided with well location, well log, and screened interval.
- (4) Identify the geologic materials being used as aquifers. Note that geologic formations may be comprised of multiple layered strata and that materials used as an aquifer may be limited to discrete layers of a specific formation. Using maps of geologic formations within the 4-mile TDL and/or cross-sections of the geology, mark all geologic materials being used as an aquifer. The boundaries of the geologic materials being used as an aquifer represent the initial identification of aquifers and their boundaries for HRS purposes.
- (5) Evaluate aquifer boundaries by examining physical relationships between geologic materials used as aquifers, as follows:
 - If geologic materials are used as aquifers, are in contact with one another within the TDL, and have hydraulic conductivities within two orders of magnitude, then combine the materials into a single aquifer for HRS purposes (see *Highlights 7-4* and *7-5*). Specific exceptions and/or clarifications to this rule are provided in *Highlights 7-6* and *7-7*.

HIGHLIGHT 7-4 COMBINING HORIZONTAL FORMATIONS (formations are shown in cross-section)

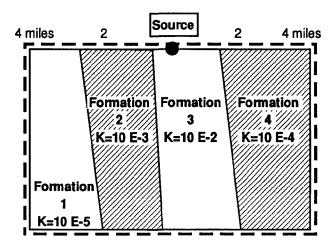


- All three geologic formations are used as aquifers within the TDL.
- Formations 1 and 2 are in direct contact, and Formations 2 and 3 are in direct contact.
- The hydraulic conductivities for all three formations are within two orders of magnitude of adjacent formations.
- Therefore, there is no aquifer boundary between Formations 1 and 2, or between Formations 2 and 3; Formations 1, 2, and 3 are combined into a single hydrologic unit (i.e., aquifer) for HRS scoring purposes.



- Formations 1 and 3 are used as aquifers.
- Although no specific information is available for Formation 2, there is no evidence of use.
- Therefore, until more information becomes available, Formation 2 is an aquifer boundary for Formations 1 and 3; thus, Formations 1 and 3 are evaluated as separate aquifers. The documentation of an aquifer interconnection between Formations 1 and 3 would result in combining the formations into a single aquifer.

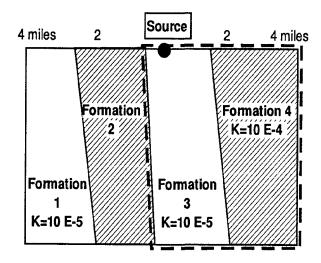
HIGHLIGHT 7-5 COMBINING VERTICAL FORMATIONS (formations are shown in cross-section)



- All four formations are used as aquifers within the TDL.
- Hydraulic conductivity (K) of each the formation (provided in units of centimeters per second; therefore, 10 E-4 = 0.0001 cm/sec) is within two orders of magnitude of the hydraulic conductivities of adjacent formations.
- No aquifer boundaries exist between Formation 3 (which underlies the site) and Formations 1, 2, and
 4.
- Therefore, Formations 1, 2, 3, and 4 are combined into a single hydrologic unit (i.e., aquifer).

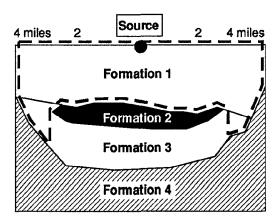
HIGHLIGHT 7-6 COMBINING VERTICAL FORMATIONS WITH DIFFERENCES IN HYDRAULIC CONDUCTIVITY

(formations are shown in cross-section)



- All four formations are used as aquifers within the TDL. Formation 3 underlies sources at the site.
- The hydraulic conductivities of Formations 1, 3, and 4 shown in the diagram are provided in cm/sec; no information exists on the hydraulic conductivity of Formation 2.
- Formation 3 and Formation 4 have hydraulic conductivities within two orders of magnitude; thus, no aquifer boundary exists between Formations 3 and 4.
- Formation 2 is considered an aquifer boundary because no hydraulic conductivity information is available and no aquifer interconnection has been documented between Formation 2 and Formations 1 or 3.
- Therefore, Formations 3 and 4 are combined into a single hydrologic unit (i.e., aquifer). Formations
 1 and 2 are not evaluated as aquifers because neither underlies sources at the site or areas of contamination attributable to the site.

HIGHLIGHT 7-7 DELINEATING AQUIFER WHEN A BOUNDARY IS CONTINUOUS THROUGHOUT 2-MILE DISTANCE (formations are shown in cross-section)



- Four formations underlie the site within the TDL.
- Formations 1 and 3 are very similar in nature and are both used as aquifers within the TDL.
- Formations 2 and 4 are not used as aquifers and are low hydraulic conductivity layers relative to Formations 1 and 3. Therefore, they are aquifer boundaries.
- Formations 1 and 3 are in direct contact within the TDL but are completely separated by a low hydraulic conductivity layer throughout the 2-mile radius.
- Therefore, the portion of Formations 1 and 3 that are in direct contact are combined into a single hydrologic unit (i.e., aquifer) indicated by dashed lines on the figure. Those portions separated by the aquifer boundary are excluded unless an aquifer interconnection can be documented between Formations 1 and 3 within the 2-mile radius.
- If Formation 2 did not underlie Formation 1 throughout the entire 2-mile radius, Formation 1 would be combined with all of Formation 3 for HRS scoring purposes.

• If materials used as aquifers are not in contact within the TDL, evaluate the potential for aquifer interconnections, as explained in the subsection below, Identifying Aquifer Interconnections. Where interconnections exist, combine the boundaries of the interconnected materials into a single aquifer for HRS purposes.

Continue with Step (5) until aquifer boundaries are documented sufficiently to support an accurate ground water pathway score, or until all primary and secondary sources of data have been exhausted. Evaluate the need for tertiary data on a case-by-case basis.

- (6) Identify aquifer discontinuities. See subsection below, Identifying Aquifer Discontinuities. Where discontinuities are identified, restrict aquifer boundaries as specified in HRS section 3.0.1.2.2. Use all information to evaluate aquifer boundaries to determine if discontinuities exist. If this information does not indicate the presence of potential discontinuities, assume that no discontinuities are present. However, the identification of potential discontinuities to be evaluated further is subject to professional judgment. As necessary, collect further information until all potential discontinuities have been evaluated and incorporated into aquifer boundaries, as appropriate. If aquifer boundaries (including discontinuities) are identified within two miles of sources at the site or within areas underlying ground water contamination attributable to the site (if contamination extends beyond two miles), proceed to Step (7). Otherwise, use the information gathered to identify those aquifers to be scored.
- (7) **Identify aquifer Interconnections.** See subsection below, Identifying Aquifer Interconnections. Where interconnections are identified, combine the aquifers having interconnections in scoring the ground water pathway. If data are not adequate to establish aquifer interconnections, only evaluate aquifers that underlie sources at the site.

IDENTIFYING AQUIFER DISCONTINUITIES

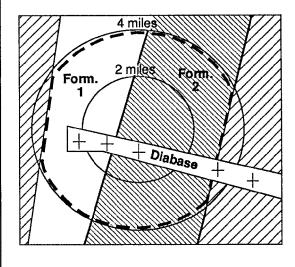
Aquifer discontinuities are physical barriers to flow and <u>do not include</u> boundaries based on ground water flow directions (e.g., ground water divides and ground water discharge boundaries). To be considered an aquifer discontinuity, the feature must entirely transect the aquifer(s) being evaluated. Examples of aquifer discontinuities include major faults, intrusive formations (e.g., dikes, sills), erosional channels (e.g., rivers, streams), and large bodies of water (e.g., lakes, bays, estuaries, and oceans).

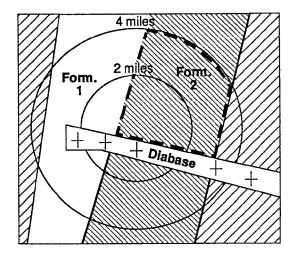
Sources of evidence for aquifer discontinuities include geologic maps, scientific literature, and topographic maps. In general, any geologic or hydrologic features that are mapped or described and appear to be of sufficient size to transect an aquifer should be considered a potential discontinuity. If sufficient information has been collected to identify aquifer boundaries and ground water targets and no discontinuities are identified, it can be assumed for HRS scoring purposes that no discontinuities exist. When a potential discontinuity is identified, evaluate the data to determine:

- If the discontinuity entirely transects the aquifer(s) being evaluated within the TDL; for
 interconnected aquifers, a discontinuity must transect the entire interconnected unit (see
 Highlight 7-8); and
- If the discontinuity disrupts the flow of ground water and hazardous substances between the materials on opposite sides of the discontinuity (i.e., a discontinuity does not exist if hazardous substances have been shown to migrate across the potential discontinuity within the TDL).

To evaluate whether the feature entirely transects. an aquifer, rely on geologic maps and cross-sections. For erosional channels such as streams and rivers, knowledge of the depth of the channels with respect to the depth (thickness) of the aquifer usually is sufficient.

HIGHLIGHT 7-8 DELINEATING AQUIFER WHEN BOUNDARY PARTIALLY TRANSECTS AQUIFER





Scenario A

Scenario B

Scenario A

- Formations 1 and 2 are in direct contact, both are used as aquifers, and they have similar hydraulic conductivities; thus, no aquifer boundaries are established between Formations 1 and 2, and they are considered a single hydrologic unit.
- A diabase dike (an intrusive, igneous rock) cuts across the formations; the diabase extends to depths below the bottom of Formations 1 and 2.
- The diabase has a significantly lower hydraulic conductivity than Formations 1 and 2.
- Since Formations 1 and 2 are combined into one aquifer for scoring purposes, the diabase is not considered a discontinuity because it does not entirely transect the aquifer being scored.

Scenario B

- Only Formation 2 is used as an aquifer. Formation 1 has a significantly lower hydraulic conductivity than Formation 2.
- A diabase dike of significantly lower hydraulic conductivity cuts across Formation 2.
- The diabase forms an aquifer discontinuity for Formation 2. Because only the dashed portion of the formation underlies sources at the site, only that portion is evaluated.

To show that the feature disrupts the exchange of ground water and hazardous substances, use the guidance below for documenting aquifer interconnections. If an aquifer interconnection can be documented, the feature being evaluated does not represent an aquifer discontinuity for HRS scoring purposes.

IDENTIFYING AQUIFER INTERCONNECTIONS

Evaluate the presence of aquifer interconnections only if aquifer boundaries and discontinuities occur within 2 miles of sources at the site (or within areas underlying ground water contamination attributable to the site). To identify an aquifer interconnection, evaluate the ability of nonaquifer materials occurring between aquifers to transfer ground water and hazardous substances. Where the nature of the intervening materials and/or features penetrating the intervening materials allows for such transfer with minimal or no disruption in flow path or velocity, consider the aquifers interconnected.

Precise definitions are not available for determining when intervening materials would have "minimal or no disruption" on hazardous substance and ground water flow. Howev**#lighlights 7-9** through **7-13** are provided as guidance for identifying aquifer interconnections. The principles inherent in these highlights are applicable to a wide variety of sites. To summarize, aquifers generally can be considered interconnected if one or more of the following is true:

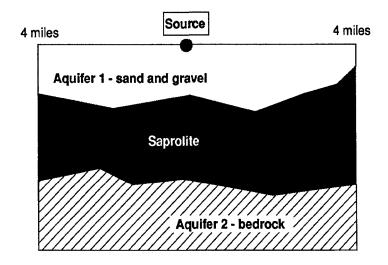
- There are no intervening materials of significantly (i.e., more than two orders of magnitude) lower hydraulic conductivity (se**tlighlight 7-9**).
- There is no continuous, significantly lower hydraulic conductivity layer that separates the two aquifers throughout the 2-mile radius. Well logs can frequently be used to establish that intervening layers are continuous (se**Highlight 7-10**).
- Contamination has been shown to have migrated across an aquifer boundary separating
 the aquifers. The flow of non-hazardous substances between aquifers can also be used
 to evaluate the potential for flow of hazardous substances between aquifers (see
 Highlight 7-11).
- Aquifer test (pumping test) data show that pumping in one aquifer has a measurable impact on water levels in another aquifer(s). The interconnection is established at the location of the well being pumped (sed-lighlight 7-12).
- Numerous man-made conduits occur through and/or across the aquifer boundaries that separate the aquifers. The numbers and sizes of man-made conduits considered sufficient to document an interconnection cannot be defined; this determination is made on a site-specific basis. (see**Highlight 7-13**).

Information to establish aquifer interconnections for HRS scoring is most commonly available for geologic settings comparable to Highlights 7-9 and 7-10. This information is typically collected during the evaluation of aquifer boundaries. Data to support evaluations comparable Highlights 7-11 and 7-12 are typically based on studies performed by others outside the scope of an SI. The situation illustrated in Highlight 7-13 occurs less frequently than the situations presented i Highlights 7-11 and 7-12. For most sites where none of the above-listed principles apply to site-specific data, aquifer interconnections are not likely to be documented.

This section presents criteria that have been used to document aquifer interconnections at NPL sites. Although these principles can be applied across a wide variety of sites and geologic settings, other types of data may be used for determining aquifer interconnections. An aquifer interconnection can be based on any hydrogeologic information that shows that an aquifer boundary between two aquifers would have no or minimal disruption on the flow of ground water or contaminants between the aquifers.

HIGHLIGHT 7-9 HORIZONTAL AQUIFERS SEPARATED BY FORMATION OF SIMILAR HYDRAULIC CONDUCTIVITY

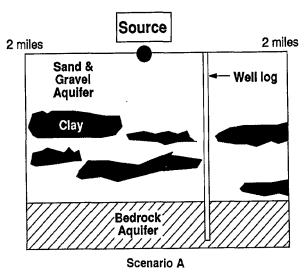
(formations are shown in cross-section)



- An upper sand and gravel aquifer is separated from an underlying bedrock aquifer by a layer of saprolite (i.e., weathered bedrock).
- The underlying bedrock is a moderately permeable igneous rock.
- The saprolite is not used as an aquifer.
- Geologic information indicates that the saprolite is the equivalent of a fine-grained, poorly sorted sand.
- Based on HRS Table 3-6, the hydraulic conductivities of the formations are as follows:
 - sand and gravel 10⁻² cm/sec
 - bedrock (moderately permeable igneous rock) 10⁻⁴ cm/sec
 - saprolite (equivalent of a fine-grained, poorly sorted sand) 10⁻⁴ cm/sec
- Although the intervening saprolite is not used as an aquifer, it does <u>not</u> have a hydraulic conductivity more than two orders of magnitude lower than the sand and gravel aquifer.
- Because the sand and gravel aquifer and the bedrock aquifer are not separated by a layer of significantly lower hydraulic conductivity, the aquifers are considered interconnected and combined into a single hydrologic unit for HRS scoring purposes.

HIGHLIGHT 7-10 USING WELL LOGS TO ASSESS AQUIFER INTERCONNECTION (formations are shown in cross-section)

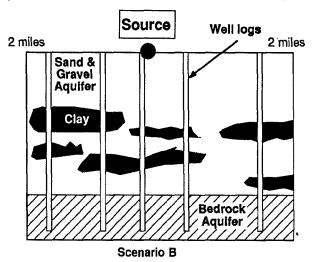
- An upper sand and gravel aquifer is separated from an underlying bedrock aquifer by a layer of interbedded sands and clays.
- Different log results are presented for each of three scenarios below. In all scenarios, well logs at the
 site show that drinking water wells are screened in sands and gravels above 30 feet in depth or in
 bedrock below 70 feet in depth; no wells are screened at depths correlating with the interbedded zone
 of sands and clays.
- The upper (sand and gravel) aquifer has the same hydraulic conductivity as the lower (bedrock)
 aquifer. Also, the sand zones between the aquifers have the same hydraulic conductivity as the
 aquifers. In contrast, the clay zones are of significantly lower hydraulic conductivity relative to the
 aquifers.
- Aquifer interconnections can be identified as follows:



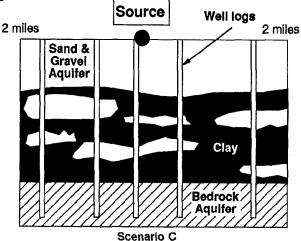
A well log within the 2-mile radius shows a location where no clay layer (or other layers of significantly lower hydraulic conductivity) separate the surficial and bedrock aquifers. The upper (sand and gravel) and lower (bedrock) aquifers are combined for HRS scoring purposes because there is not a continuous layer of significantly lower hydraulic conductivity that separates the two aquifers throughout the 2-mile radius. This evidence for interconnection is considered conclusive.

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HIGHLIGHT 7-10 (continued) USING WELL LOGS TO ASSESS AQUIFER INTERCONNECTION (formations are shown in cross-section)



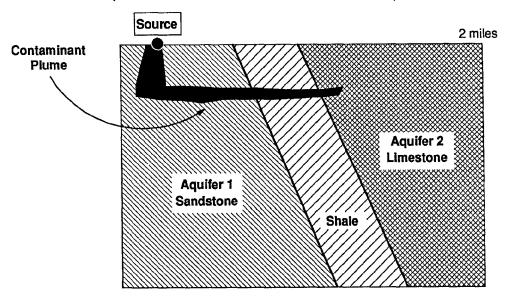
Multiple well logs show that clays are of limited extent and comprise less than 25 percent of the materials between 30 and 70 feet. The upper (sand and gravel) and lower (bedrock) aquifers are combined for HRS scoring purposes because it is assumed that there is no continuous layer of significantly lower hydraulic conductivity that separates the two aquifers throughout the 2-mile radius. The conclusion is based on a preponderance of evidence and professional judgment. The use of 25 percent in this highlight is not intended to establish a benchmark; rather, it provides a hypothetical example of the use of professional judgment in light of site-specific supporting information.



Multiple well logs show a high percentage of clay within the interbedded zone. The aquifers would <u>not</u> be considered interconnected for HRS purposes.

HIGHLIGHT 7-11 USING CONTAMINANT MIGRATION TO ASSESS AQUIFER INTERCONNECTION

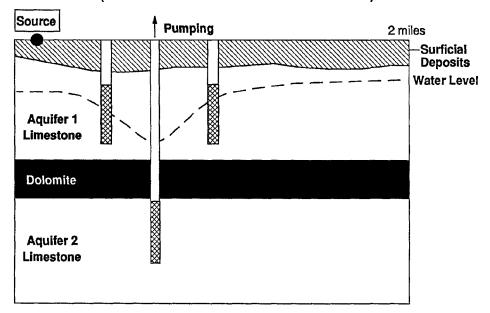
(formations are shown in cross-section)



- A series of fractured bedrock formations dip in the same direction as follows: (a) a sandstone
 formation underlies the site and is used as an aquifer, (b) adjacent to the sandstone in the downdip
 direction is a shale formation that is not used as an aquifer and is a low hydraulic conductivity layer
 relative to adjacent formations, and (c) adjacent to the shale in the downdip direction is a limestone
 formation that is used as an aquifer.
- The sandstone (Aquifer 1) and limestone (Aquifer 2) formations are separated by a shale formation
 that is not used as an aquifer and has a significantly lower hydraulic conductivity; thus, the aquifers
 are initially evaluated separately.
- Without documenting aquifer interconnections, Aquifer 1 can be scored while Aquifer 2 does not underlie the site and would not be evaluated.
- Ground water contamination has been shown to have moved from Aquifer 1 to Aquifer 2 across the shale and within the 2-mile radius. This contamination does not have to be attributable to the site.
 Also, contaminant migration from Aquifer 2 to Aquifer 1 may not be used to document an interconnection.
- Therefore, Aquifers 1 and 2 are considered interconnected and are combined into a single hydrologic unit for scoring purposes because contamination has been shown to have migrated between two aquifers across an aquifer boundary. Although the mechanism of contaminant transport does not have to be identified, sufficient evidence should be presented to eliminate other likely mechanisms for the introduction of the contaminant into the limestone aquifer.

HIGHLIGHT 7-12 USING PUMPING TEST DATA TO ASSESS AQUIFER INTERCONNECTION

(formations are shown in cross-section)

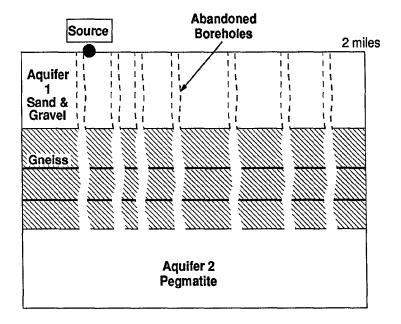


Screening Interval

- A formation is flat-lying and consists of interbedded layers of limestone and dolomite; from the surface, there is a 50-foot thickness of limestone, a 40-foot thickness of dolomite, and a 90-foot thickness of limestone.
- The limestone layers are used as aquifers while there is no indication that the dolomite is used as an aquifer.
- No information on hydraulic conductivity is available for the limestone or dolomite layers.
- Initially, the dolomite layer is considered an aquifer boundary, and the limestone aquifers are evaluated separately.
- A pumping test is conducted of the lower limestone aquifer, and water levels in the upper limestone aquifer are monitored before, during, and after the test.
- Static water level was determined in the upper limestone; fluctuations were within 8 inches.
- During pumping, water levels in the upper aquifer dropped, on average, 2 feet and 9 inches; following
 a cessation of pumping, water levels in the upper aquifer returned to static levels.
- Therefore, the upper and lower limestone aquifer are considered interconnected at the location of the
 well being pumped in the lower aquifer; the aquifer test (pumping test) data show that pumping of the
 lower aquifer has a measurable impact on water levels in the upper aquifer.

HIGHLIGHT 7-13 USING NUMEROUS MAN-MADE CONDUITS TO ASSESS AQUIFER INTERCONNECTION

(formations are shown in cross-section)



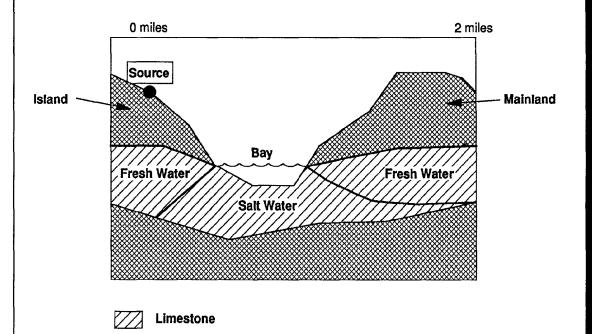
- A sand and gravel formation is separated from a fractured pegmatite (i.e., type of igneous rock) formation by a layer of gneiss (i.e., type of metamorphic rock).
- Well logs show that the sand and gravel formation and the pegmatite are used as aquifers; there is no indication that the gneiss is used as an aquifer.
- No information on hydraulic conductivity of the materials is available; initially, the sand and gravel aquifer and the pegmatite aquifer are evaluated separately.
- Historical records and well log information indicate that uncased boreholes were placed through the gnelss in order to mine the pegmatite.
- Numerous (more than 100) mining shafts could be located, based on boring logs, within 1 mile of the site; none of the borings had been sealed.
- Based on site-specific considerations, the extent, number, and type of boreholes through the gneiss
 were sufficient to conclude that the gneiss did <u>not</u> have the ability to disrupt the flow of hazardous
 substances between the sand and gravel aquifer and the pegmatite aquifer.
- Therefore the aquifers are combined for scoring purposes. The numbers and sizes of man-made conduits considered sufficient to document an interconnection cannot be precisely defined; this determination is made using professional judgment on a site-specific basis.

TIPS AND REMINDERS

- As a first step, identifying and locating wells that can potentially be evaluated as ground water targets may help to focus remaining data requirements for establishing aquifer boundaries.
 Establishing aquifer boundaries will then determine which targets are evaluated.
- Aguifers can be established in both horizontal and vertical directions.
- For unconfined (water table) aquifers, the uppermost elevation of ground water may not be known near the site; this elevation can be estimated as follows:
 - In areas where streams are known to be "gaining" (that is, ground water elevations are greater than surface water elevations resulting in ground water discharge to the surface water), the elevation of the water surface in a nearby stream can be used to determine the minimum elevation of ground water beneath the site. Note that elevations of flood stages in the stream would not be appropriate for this determination because the stream is not likely to be a "gaining" stream during the flood.
 - Using well logs, evaluate water elevation data and data on ground water flow gradients on a regional basis to approximate the top of the aquifer beneath the site. The use of this approach must be based on site-specific considerations regarding the relative accuracy of the data and the degree to which the site data fits within appropriate HRS ranges.
- For confined aquifers, evaluate the top of the aquifer based on regional well logs, information on degree and direction of formation dip, and geologic maps.
- A body of salt water can form an aquifer boundary with the boundary defined by the location of
 the fresh water/salt water interface. Variations in the location of the interface would potentially
 represent variations in an aquifer boundary (this is not expected to affect the HRS evaluation of
 most sites because fresh water wells generally are not located within the zone of variation of the
 fresh water/salt water interface).
- The presence of fractures in a geologic material does not in itself establish the material as an aquifer or disqualify the material as an aquifer boundary; rather, the ability of the fractures to transmit water and the overall hydraulic conductivity of the material are the key data to consider (e.g., materials can be fractured and still have relatively low hydraulic conductivities).
- Information on use of a geologic material as an aquifer outside the TDL does <u>not</u> qualify the same material as an aquifer within the TDL; there must be specific information on use within the TDL. However, use of the materials as an aquifer outside the TDL could be used to evaluate whether the material is an aquifer boundary inside the TDL. Specifically, professional judgment should be used to evaluate whether properties of the material where it is being used as an aquifer are likely to be representative of the materials within the TDL.
- Evaluate aquifer discontinuities within the 4-mile TDL.
- An aquifer discontinuity must be a physical barrier that entirely transects all geologic materials combined into a single hydrologic unit for scoring purposes, or else the discontinuity is not evaluated.
- If hazardous substances have migrated across a potential discontinuity in the direction of flow from the site, do not consider this a discontinuity.

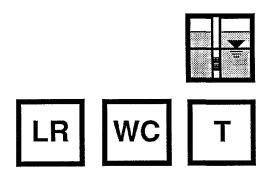
- Bodies of salt water, if they entirely transect an aquifer, would be considered a discontinuity (see Highlight 7-14).
- Ground water flow gradients and related features, such as ground water divides (e.g., ridges, topographic highs), are not sufficient by themselves to establish a discontinuity.
- Aquifer interconnections cannot be assumed, but must be supported by evidence.
- Evaluate interconnections within 2 miles of sources at the site or within areas underlying ground water contamination attributable to the site (if contamination extends beyond two miles).
- Where aquifer interconnections are documented, combine all interconnected aquifers and intervening materials into a single hydrologic unit for HRS scoring purposes.
- Computer models have not been used to demonstrate interconnections. Documenting that the
 assumptions used to construct and run models accurately represent hydrogeologic conditions
 throughout the 2-mile distance for aquifer interconnections and the 4-mile TDL has not been
 possible.

HIGHLIGHT 7-14 BODIES OF SALT WATER AS AQUIFER DISCONTINUITIES (formations are shown in cross-section)



- A limestone formation is continuous between the mainland and a nearby island; a salt-water bay separates the island from the mainland.
- The limestone is used as an aquifer on both the mainland and the nearby island.
- Salt water occupies the limestone formation for its entire thickness beneath the bay.
- The bay is considered an aquifer discontinuity and the freshwater zones are two separate aquifers for HRS purposes. The aquifer that underlies the sources at the site (i.e., under the island) would be evaluated. The aquifer under the mainland would not be evaluated as it does not underlie sources at the site, and it is not in direct contact or interconnected with an aquifer that does.

SECTION 7.2 TREATMENT OF KARST



This section provides guidance on the identification of karst terrain and karst aquifers and on the treatment of karst in the HRS evaluation of the ground water pathway. Guidance provided in Section 7.1 on identification of aquifers also applies in karst terrain and should be consulted in conjunction with this section.

Karst refers to a characteristic of a geologic material or formation resulting from the dissolution of the formation by natural waters over time. Because of the dissolution cavities and the channels that comprise them, karst aquifers are considered extremely vulnerable to contamination. The movement of hazardous substances released into karst aquifers is highly unpredictable, and transport over relatively long distances can occur very rapidly. For these reasons, a karst aquifer that underlies any portion of the sources at the site is given special consideration in the evaluation of several HRS factors within potential to release, waste characteristics, and targets. These factors are:

- Potential to Release
 - Depth to aguifer
 - Travel time
- Waste Characteristics
 - Mobility
- Targets
 - Nearest well
 - Population/potential contamination

At sites evaluated for potential to release (i.e., no observed release is documented), several specific considerations for scoring karst aquifers apply. For sites with a documented observed release (i.e., hazardous substances attributable to the site have reached the aquifer being evaluated) and targets subject to actual contamination, there are few, if any, specific scoring considerations for karst aquifers.

For purposes of identifying aquifers and establishing aquifer boundaries, karst is evaluated in the same manner as any other geologic formation. For each of the factors that is treated differently for karst aquifers, a highlight presented in this section compares the general scoring steps for a karst aquifer with those for aquifers without karst characteristics.

RELEVANT HRS SECTIONS

Section 1.1	Definitions (karst)
Section 3.0.1.3	Karst aquifer
Section 3.1.2.3	Depth to aquifer
Section 3.1.2.4	Travel time
Section 3.2.1.2	Mobility
Section 3.3.1	Nearest well
Section 3.3.2.2	Level I concentrations
Section 3.3.2.3	Level II concentrations
Section 3.3.2.4	Potential contamination

DEFINITIONS

Karst: A kind of terrain with characteristics of relief and drainage arising from a high degree of rock solubility. The majority of karst conditions occur in limestone areas, but karst may also occur in areas of dolomite, gypsum, or salt deposits. Features associated with karst terrain may include irregular topography, abrupt ridges, sinkholes, caverns, abundant springs, disappearing streams, and the lack of a well-developed surface drainage system of tributaries and streams. Karst aquifers generally are associated with karst terrain on the surface. Karst aquifers at depth may not be associated with karst terrain.

IDENTIFYING KARST

To identify karst, determine the structures and features that characterize karst. This information is often contained within the scientific literature and other primary data sources for determining aquifer boundaries, as described in Section 7.1.

- (1) Use geologic maps and other readily available Information to determine If karat features are expected within 4 miles of the site. A map of the entire United States that indicates areas containing karst features is published by USGS; using this map, Engineering Aspects of Karst (document number 38077-AW-NA-07M-00), it is possible to determine if karst features are predicted in the site vicinity. Because of the large scale of this map, scorers should also review site-specific information, including more detailed geologic maps. Where information is uncovered to identify a karst formation within the TDL, continue with the following steps.
- (2) Compile the available site-specific evidence that Indicates the presence of karat Note on a map locations with evidence of a karst feature (e.g., spring, disappearing stream, sinkhole, or cave); such information can be obtained from topographic maps, aerial photographs, maps of caves, and visual observations. Also, well logs that note a drop of several feet in the bit during drilling may be indicative of karst features.
 - It is generally impractical at the level of an SI to perform adequate field investigations to identify and evaluate the extent of a karst material. Thus, existing information will be the basis for identification of karst. However, where information is available prior to the SI to indicate the possible presence of karst, limited field checks for karst features in the area of the site may be compatible with the level of effort normally associated with an SI.
- (3) **Estimate the lateral extent of karat.** Based on the distribution of the karst features within the formation, use professional judgment to delineate laterally the areas containing karst features.
- (4) **Estimate the thickness of karat.** While the lateral extent of karst is based on visual observations and surface expressions, it can be more difficult to determine the thickness of

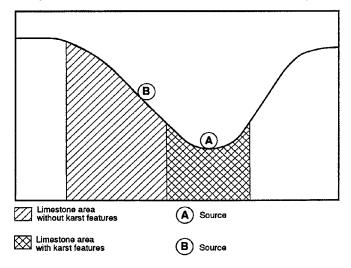
karst. As an initial determination, the depth and thickness of the formation(s) containing the karst features should be evaluated. Determining formation depth and thickness for aquifers that underlie sources at the site is especially important for HRS scoring purposes. Indications of depth and thickness may be available from well log data, scientific literature, or other information compiled during the evaluation of aquifer boundaries.

(5) **Define the aquifer boundaries for karst aquifers**. The boundary between karst and adjacent materials is based on the boundary between karst and non-karst characteristics (sed**Highlight 7-15**).

To identify karst aquifer boundaries, start with geologic maps and information compiled during the identification and definition of aquifers. Based on this information, compile a list of geologic materials and/or formations that are known to contain karst features. Also note whether the information indicates the presence of karst features under sources at the site, within the 4-mile radius, or regionally. In those formations with karst features, evaluate the lateral and vertical extent of karst within the TDL, as described above.

(6) Identify wells that draw drinking water from a karst aquifer that underlies sources at the site. These drinking water wells qualify for special consideration when scoring potential contamination.

HIGHLIGHT 7-15 DEFINING BOUNDARIES FOR A KARST AQUIFER (formations are shown in cross-section)



The extent of a karst aquifer or formation for HRS purposes is based on the extent of the structures and features associated with karst. Where these structures or features are not present, the rapid and highly unpredictable movement of ground water associated with karst would not be expected, and special scoring considerations in the ground water pathway would not be appropriate. In this example, a limestone formation forms part of both a valley wall and valley floor. The karst characteristics are present along the valley floor but do not occur along the valley wall. An aquifer underlying Source A would be scored as a karst aquifer, because the portion of limestone formation along the valley floor would be considered karst. An aquifer underlying Source B would not be scored as a karst aquifer, however, because the features leading to rapid ground water flow do not underlie this source.

SCORING DIFFERENCES FOR KARST AQUIFERS

The highlights on the following pages contrast the scoring procedures for each of the factors that is scored differently (i.e., depth to aquifer, travel time, mobility, nearest well, population/potential contamination) for karst and non-karst aquifers.

Before using these highlights, review *Highlight 7-16* to determine which of the factors need to be cored for the aquifer under evaluation. This highlight divides aquifers depending on how the likelihood of release factor is evaluated (i.e., observed release by chemical analysis, observed release by direct observation, potential to release) and by how targets are evaluated (i.e., actual contamination only, potential contamination with or without actual contamination). For each scoring situation, factors that may receive special consideration for karst aquifers are listed. Remember, these special considerations apply only to karst aquifers underlying at least a portion of the sources at the site.

When karst aquifers are present, there are either differences from the scoring procedures or additions to the scoring procedures used in non-karst situations. In *Highlights 7-17* to *7-21*, which explain these differences, the following key is used:

- A bullet (followed by text) in the "non-karst" column and no bullet in the "differences due to karst" column: "non-karst" evaluation step is <u>used without change</u> in evaluating a karst aquifer.
- Directly parallel bullets in columns labelled "non-karst" and "differences due to karst": step in the "differences due to karst" column replaces the opposing "non-karst" step.
- A bullet in the "differences due to karst" column has no parallel bullet in the "non-karst' column: "differences due to karst" step is <u>in addition</u> to the steps in the "non-karst" column.

These highlights are designed to summarize key differences, not to provide detailed scoring instructions.

HIGHLIGHT 7-16 HRS FACTOR GIVEN SPECIAL CONSIDERATION FOR KARST AQUIFERS

		Type of Drinking Water Targets in Karst Aquifer			
		Evaluated Under Actual Contamination Only	Some or All Evaluated Under Potential Contamination		
Type of	Observed Release by Chemical Analysis	Mobility (for hazardous substances that don't meet observed release criteria)	Population/Potential Contamination Mobility (for hazardous substances that don't meet observed release criteria)		
Likelihood of Release Evaluation In Karst Aquifer	Observed Release by Direct Observation	Mobility (for all hazardous substances)	Mobility (for all hazardous substances) Nearest Well Population/Potential Contamination		
	Potential to Release	Combination never occurs	All five factors may be given special consideration		

HIGHLIGHT 7-17 SCORING CONSIDERATIONS FOR KARST AQUIFERS: DEPTH TO AQUIFER FACTOR

Non-karst	Differences Due to Karst
 Determine the depth to aquifer only at locations within 2 miles of the sources at the site, except: if observed ground water contamination attributable to sources at the site extends more than 2 miles beyond these sources, use any location within the limits of this observed ground water contamination when evaluating the depth to aquifer for any aquifer that does not have an observed release. Evaluate the depth to an aquifer as the distance from the surface to the top of the aquifer minus the distance from the surface to the lowest known point of hazardous substance eligible to be evaluated for that aquifer. 	
	 In evaluating depth to aquifer in karst terrain, assign a thickness of 0 feet to a karst aquifer that underlies any portion o the sources at the site.
Based on the calculated depth, assign a value from HRS Table 3-5 to the depth to aquifer factor.	

HIGHLIGHT 7-18 SCORING CONSIDERATIONS FOR KARST AQUIFERS: TRAVEL TIME FACTOR

	Non-karst		Differences Due to Karst
•	Determine the travel time only at locations within 2 miles of the sources at the site, with the same exception as in evaluating depth to aquifer (see <i>Highlight 7-17</i>).		
•	Evaluate travel time factor based on the geologic materials In the interval between the lowest known point of hazardous substances at the site and the top of the aquifer being evaluated.		
•	If the depth to aquifer is 10 feet or less, assign a factor value of 35 and skip the remaining steps for travel time.		
		•	If, for the interval being evaluated, all layers that underlie a portion of the sources at the site are karst, assign a factor value of 35 and skip the remaining steps for travel time.
•	Determine hydraulic conductivities for Individual layers from HRS Table 3-6 or from in-situ or laboratory tests. Use representative, measured hydraulic conductivity values whenever available.		
•	Otherwise, select the lowest hydraulic conductivity layer(s) from within the above interval. Consider only layers at least 3 feet thick. However, do not consider layers or portions of layers within the first 10 feet of the depth to the aquifer.		
		•	Assign a thickness of 0 feet to a karst layer that underlies any portion of the sources at the site.
•	If more than one layer has the same lowest hydraulic conductivity, Include all such layers and sum their thicknesses.		
•	Assign a value from HRS Table 3-7 to the travel time factor, based on the thickness and hydraulic conductivity of the lowest hydraulic conductivity layer(s).		

HIGHLIGHT 7-19 SCORING CONSIDERATIONS FOR KARST AQUIFERS: MOBILITY FACTOR

	Non-karst		Differences Due to Karst
•	For any hazardous substance that meets the criteria for an observed release by chemical analysis to one or more aquifers underlying the sources at the site regardless of the aquifer being evaluated, assign a mobility factor value of 1.		
•	For any hazardous substance that $\underline{\text{does not meet}}$ the criteria for an observed release by chemical $\underline{\text{analysis}}$ to at least one of the aquifers, assign a mobility factor value from HRS Table 3-8 for the aquifer being evaluated based on its water solubility and distribution coefficient (K_{d}).		
•	See HRS section 3.2.1.2 to determine the water solubility to be used in HRS Table 3-8 for the hazardous substance.		
•	See HRS section 3.2.1.2 to determine the distribution coefficient to be used in HRS Table 3-8 for the hazardous substance. Use either the distribution coefficient categories "# 10", " > 10 to 1,000", or ">1,000", as appropriate, if part or all of the interval from a source to the aquifer is not karst.	•	If the entire interval from a source at the site to the aquifer being evaluated is karst, use the distribution coefficient category "Karst" in HRS Table 3-8 in assigning the mobility factor value. If karst is present in the interval, but the entire interval is not karst, then use the step listed under "non-karst" instead of the step in this column.
•	If a hazardous substance cannot be assigned a mobility factor value because data on its water solubility or distribution coefficient are not available, use other hazardous substances for which information is available in evaluating the pathway.	•	If a hazardous substance cannot be assigned a mobility factor value because data on its water solubility are not available and the entire interval is karst, use other hazardous substances for which solubility information is available to evaluate the pathway. I karst is present in the interval, but the entire interval is not karst, then use the step listed under "non-karst" instead of the step in this column.
•	If none of the hazardous substances eligible to be evaluated can be assigned a mobility factor value, use a default value of 0.002 as the mobility factor value for all these hazardous substances.		

HIGHLIGHT 7-20 SCORING CONSIDERATIONS FOR KARST AQUIFERS: NEAREST WELL FACTOR

	Non-karst	Differences Due to Karst
•	If for the aquifer being evaluated, there is an observed release by direct observation for a drinking water well within the TDL, assign Level 11 concentrations to the well.	
•	However, if one or more samples meet the criteria for an observed release for a target well for the aquifer, determine if that well is subject to Level I or Level II concentrations as specified in HRS section 2.5.1 and 2.5.2.	
•	If one or more target drinking water wells for the aquifer are subject to Level I concentrations, assign a factor value of 50.	
•	If not, but if one or more target drinking water wells for the aquifer are subject to Level II concentrations, assign a factor value of 45.	
•	If none of the target drinking water wells is subject to Level I or Level II concentrations for the aquifer, determine the shortest distance to any drinking water well for the aquifer, as measured from any source at the site with a ground water containment factor value greater than 0. Select a value from HRS Table 3-11 based on this distance. Assign it as the value for the nearest well factor for the aquifer.	If none of the target drinking water wells is subject to Level I or Level II concentrations for the aquifer, and if one of the aquifers being evaluated is a karst aquifer that underlies any portion of the sources at the site, and if any well draws drinking water from this karst aquifer within the TDL, assign a value of 20 for the nearest well factor for the aquifer.

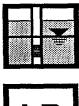
HIGHLIGHT 7-21 SCORING CONSIDERATIONS FOR KARST AQUIFERS: POPULATION/POTENTIAL CONTAMINATION FACTOR

	Non-karat		Differences Due to Karst
•	Determine the number of people served by drinking water from points of withdrawal (for the aquifer being evaluated) subject to potential contamination. Do not include those people already counted under Level I and/or Level II concentration factors.		
		•	Use the "Karst' portion of HRS Table 3-12 to assign values only for that portion of the target population served by points of withdrawal that draw drinking water from a karst aquifer that underlies any portion of the sources at the site.
!	Use the "Non-karst" portion of HRS Table 3-12 for that portion of the target population served by points of withdrawal subject to potential contamination, excluding any points of withdrawal that draw drinking water from a karst aquifer that underlies any portion of the sources at the site.		
!	Calculate the value for the population/potential contamination factor as directed in HRS section 3.3.2.4.		

TIPS AND REMINDERS

- Karst aquifers that do <u>not</u> underlie any portion of site sources are evaluated in the same manner as non-karst aquifers.
- A significant percentage of karst in the U.S. occurs in limestone. The presence of springs, sinkholes and caverns in a limestone formation may be indicative of karst.
- Lava aquifers or aquifers with numerous abandoned mine shafts do not meet the HRS definition
 of karst and, even though hazardous substance transport may be facilitated in such aquifers,
 they cannot be considered karst aquifers for purposes of HRS scoring.

SECTION 7.3 CONTAINMENT FACTOR





This section provides definitions for many of the terms used in the ground water containment descriptions and explains how to score the containment factor. If an observed release to an aquifer cannot be established, then that aquifer is evaluated based on potential to release. Four factors are used to evaluate the potential to release factor: containment, net precipitation, depth to aquifer, and travel time. The containment factor is a measure of the methods (either natural or engineered) that have been used to restrict the release of hazardous substances from a source to the subsurface or to prevent released substances from entering ground water.

Containment criteria have been compiled for several types of sources on a numerical scale selected to provide a relative degree of discrimination among different levels of containment. HIRS Table 3-2 includes containment factor rating descriptions for the following specific categories of hazardous waste sources: surface impoundments, land treatment facilities, containers, and tanks. The table also provides containment factor rating descriptions that apply to all other hazardous waste sources, including landfills, piles, and contaminated soil.

The containment factor is evaluated for each source for the aquifer being evaluated, and the highest containment factor value for any source that meets the minimum size requirement is assigned as the containment factor value. If none of the sources meets the minimum size requirement, the highest containment factor value of any source is assigned.

RELEVANT HRS SECTION

Section 3.1.2.1

Containment

DEFINITIONS

3-2.

The following definitions elaborate on terms used in the containment descriptions in HRS Table

Above-ground Tank: Any tank that does not meet the definition of a below-ground tank (including any tank that is only partially below the surface).

Associated Containment Structures: As used in HRS Table 3-2, constructed barriers (e.g., liners, dikes, berms) that may have been placed under, over, or around a source (e.g., a landfill or a waste pile) to prevent the release of hazardous substances to the environment.

Below-ground Tank: A tank with its entire surface area below the surface and not visible; however, a fraction of its associated piping may be above the surface.

Bulk Liquids: Noncontainerized liquids deposited directly into a source by pipe, tanker truck, or other means of transport.

Essentially Impervious Base: A base underlying containers that is free from cracks and gaps and prevents penetration of leaks, spills, or precipitation.

Evidence of Hazardous Substance Migration: Chemical analyses and/or visual evidence that demonstrate hazardous substances attributable to a source have migrated away from that source into the surrounding soil, ground water, surface water, or air (e.g., leachate, containing hazardous substances coming out of the source; stained or contaminated soil that can be attributed to migration from the source; evidence of the overflow from a surface impoundment containing hazardous substances).

Free Liquids: Liquids that readily separate from the solid portion of a substance under ambient temperature and pressure.

Freeboard: Vertical distance between the top of a tank or surface impoundment dike and the surface of the hazardous substance contained therein. Freeboard is intended to prevent overtopping resulting from normal or abnormal operations, wind and wave action, rainfall, and/or run-on.

Functioning Ground Water Monitoring System: A system of test wells installed around a source to detect migration of hazardous substances. In evaluating the containment factor in the ground water pathway, wells should be sampled and maintained to constitute a functioning ground water monitoring system.

Land Treatment Zone: Soil layer in the unsaturated zone of a land treatment unit within which hazardous substances are intended to be degraded, transformed, or immobilized.

Liner: A continuous barrier that covers all the earth likely to be in contact with a source so that hazardous substances or leachate containing hazardous substances would not migrate to the surrounding earth. The barrier may be synthetic material (e.g., a thick, continuous, polyethylene membrane) or engineered, compacted, natural material (e.g., re-worked and low permeability clay). An in-situ clay layer that has not been re-engineered by compaction or other methods is not considered a liner.

Maintained Engineered Cover: Vegetated cover, usually made of compacted clean soil. It is generally placed over a source at its closure and is designed and constructed to minimize the migration of liquids through the closed source, function with minimum maintenance, and accommodate settling and subsidence. Maintenance of the integrity and effectiveness of the final cover may include repairing it as necessary to correct the effects of settling, subsidence, erosion, and other events.

Secondary Containment: As used in HRS Table 3-2, secondary containment is applicable to the evaluation of the containment factor for tanks. Methods of secondary containment include a liner external to the tank, a vault, a double-walled tank, or an equivalent device.

Tank and Ancillary Equipment: Tanks and associated pipes, pumps, sumps, manifolds, fittings, flanges, and valves used to distribute, meter, or control flow of hazardous substances to or from the tank.

SCORING THE GROUND WATER CONTAINMENT FACTOR

(1) Identify the sources at the site. HRS section 1.1 defines a source as many area where a hazardous substance has been deposited, stored, disposed, or placed, plus those soils that have become contaminated from migration of a hazardous substance.0 The HRS divides sources into five categories for evaluating ground water containment: surface impoundments, land treatment, containers, tanks, and all other sources. Each category has a separate list of criteria used to assign containment values.

- (2) Use HRS Table 3-2 to assign a containment value to each source. Use the definitions provided above to interpret the criteria in Table 3-2. *Highlight 7-22* summarizes the types of information that generally should be collected during the SI for the purposes of evaluating the containment factor.
- (3) For each source for the aquifer being evaluated, determine whether the source hazardous waste quantity value is 0.5 or greater. Only sources with a source hazardous waste quantity value of 0.5 or greater can be used to assign the containment value, unless no source for the aquifer being evaluated has a source hazardous waste quantity value of 0.5 or greater. This limitation is referred to as the "minimum size requirement". *Highlight 7-23* summarizes the minimum measurements of sources that will give a source hazardous waste quantity value of 0.5. Any of the hazardous waste quantity tiers can be used to determine whether a source meets the minimum size requirement. Detailed guidance on determining hazardous waste quantity values is provided in Chapter 6.
- (4) Assign a pathway containment factor value for the aquifer being evaluated.
 - Assign the highest containment value for those sources with hazardous waste quantity values greater than or equal to 0.5 as the containment factor value for the ground water pathway.
 - If <u>none</u> of the sources at the site for the aquifer being evaluated has a source hazardous waste quantity value of greater than or equal to 0.5, assign the highest containment value among <u>all sources</u> as the containment factor value for the ground water pathway.

HIGHLIGHT 7-22 DATA NEEDS FOR EVALUATING SOURCE CONTAINMENT

The following types of information are helpful for evaluating the containment factor:

- The physical location of the hazardous substance(s) (e.g., buried, in a below-ground tank).
- Evidence of hazardous substance migration (e.g., overflow from surface Impoundments).
- Evidence, or lack thereof, of diking, berms, or other engineered physical barriers that completely surround the source area.
- The presence of bulk and/or free liquids.
- Evidence of liners that are continuous and that would prevent the source hazardous substance(s) from coming in contact with the earth beneath (or around) the source. In the case of liners, the site investigator may assume that there Is not a liner unless evidence indicates otherwise.
- Evidence, or lack thereof, of leachate collection systems (functioning or not), and ground water monitoring systems.
- Evidence of the existence and condition of physical structures that provide protection from precipitation, and/or run-on and runoff control.

The above list is illustrative. It is meant neither to be all inclusive of the types of information that can be used to characterize the containment of any particular hazardous substance source nor to establish minimum requirements.

HIGHLIGHT 7-23 SOURCE MEASUREMENTS THAT MEET THE MINIMUM SIZE REQUIREMENT

Tier	Measure or Source Type	Minimum Measurements for Hazardous Waste Quantity Value of 0.5
Α	Hazardous constituent quantity	0.5 pounds
В	Hazardous wastestream quantity	2,500 pounds
С	Landfill	1,250 cubic yards
Volume	Surface impoundment	1.25 cubic yards
	Surface impoundment (Buried/backfilled)	1.25 cubic yards
	Drums	250 gallons
	Tanks and containers other than drums	1.25 cubic yards
	Contaminated soil	1,250 cubic yards
	Pile	1.25 cubic yards
	Other	1.25 cubic yards
D	Landfill	1,700 square feet
Area	Surface impoundment	6.50 square feet
	Surface impoundment (buried/backfilled)	6.50 square feet
	Land treatment	135 square feet
	Pile	6.50 square feet
	Contaminated soil	17,000 square feet

TIPS AND REMINDERS

- Regardless of source type, if there is evidence of hazardous substance migration from the source, a containment factor value of 10 applies. Note that evidence of migration from a source does not have to meet the criteria for observed release.
- Every source may not be evaluated for every aquifer, depending on the location of the source
 and the hydrogeology in the area of the site. Only sources for the aquifer being evaluated are
 used in assigning the containment factor value for that aquifer.
- Only those sources that have a non-zero containment factor value for ground water should be evaluated.
- The presence of a liner that extends under the entire source area is considered when evaluating containment; if the liner does not extend under the entire source area (i.e., a partial liner), the source should be evaluated as if no liner were present. The condition of the liner (e.g., damaged, torn, or leaking) would typically not be discernible during the SI.
- A site may be considered to have a "natural" liner only if the clay underlying the site has been reworked to provide an engineered barrier. The mere existence of a natural clay layer or a confining layer is not sufficient. However, such a layer would be accounted for when evaluating the travel time factor.
- Assign a containment factor value for only those sources with a source hazardous waste quantity
 value of 0.5 or more. If no source meets this minimum size requirement, select the highest
 containment factor value among <u>all</u> sources for the aquifer being evaluated as the containment
 factor value.
- Any hazardous waste quantity tier (A, B, C, or D) can be used to determine if a source meets the
 minimum size requirement.

SECTION 7.4 ACTUAL CONTAMINATION





This section provides guidance on identifying drinking water wells subject to actual contamination, determining whether wells subject to actual contamination have Level I or Level II concentrations, and scoring sites with actual contamination. A drinking water well is subject to actual contamination if it meets specific criteria that demonstrate that the well has been contaminated by hazardous substances attributable to the site. Target drinking water wells at which actual contamination is not documented are evaluated based on potential contamination. All wells subject to actual contamination are classified as Level I or Level II. Wells subject to actual contamination receive higher values for several factors.

RELEVANT HRS SECTIONS

Section 2.3	Likelihood of release
Section 2.5	Targets
Section 2.5.1	Determination of level of actual contamination at sampling location
Section 2.5.2	Comparison to benchmarks
Section 3.1.1	Observed release
Section 3.3.1	Nearest well
Section 3.3.2.1	Level of contamination
Section 3.3.2.2	Level I concentrations
Section 3.3.2.3	Level II concentrations

DEFINITIONS

Actual Contamination In the Ground Water Pathway: A drinking water well is subject to actual contamination if a sample from the well meets the criteria for an observed release. (*Highlight* 7-24 discusses the difference between actual contamination and observed release.) Actual contamination of a drinking water well cannot be inferred based on other samples (e.g., from downgradient wells).

Level I Concentrations for the Ground Water Pathway: Level I concentrations are established in samples from drinking water wells in which the concentration of a hazardous substance that meets the criteria for an observed release is <u>at or above</u> its drinking water benchmark. A drinking water well also may be subject to Level I concentrations if multiple hazardous substances that meet the criteria for an observed release are present below their respective benchmarks, and the I or J index is greater than or equal to one. Benchmarks for the ground water pathway include MCLs, nonzero MCLGs, and screening concentrations for cancer and chronic noncancer effects.

HIGHLIGHT 7-24 COMPARISON OF ACTUAL CONTAMINATION TO OBSERVED RELEASE

Because actual contamination involves observed release as part of its definition, the two concepts are often confused. Observed release is a necessary but not sufficient condition for establishing actual contamination of specific targets. Scoring an observed release to ground water generally involves detecting a hazardous substance (attributable to the site) in ground water samples at levels significantly above background for the site. The samples that are used to score an observed release can be taken from any well - monitoring wells, drinking water wells, or other types of wells. Scoring actual contamination requires that the same criteria for an observed release be met, but the samples meeting these criteria must be taken from drinking water wells. If the only ground water samples that show hazardous substances at levels significantly above background (i.e., an observed release) are taken from monitoring wells, no actual contamination can be scored. In addition, an observed release to ground water can sometimes be scored by direct observation (e.g., by documenting deposition of hazardous substances in the aquifer). Actual contamination of a drinking water well can be documented by direct observation only if hazardous substances were disposed in the well itself or were observed entering the well, both of which are unlikely scenarios. If actual contamination cannot be scored, all targets are scored based on potential contamination. In essence, for the ground water pathway, actual contamination is a concept that applies only to targets and target locations, while observed release is not so restricted.

Level II Concentrations for the Ground Water Pathway: Level II concentrations are established in samples from drinking water wells in which the concentration of at least one hazardous substance meets the criteria for an observed release, but the conditions for Level I concentrations are not met. In addition, Level II is assigned for observed releases established by direct observation.

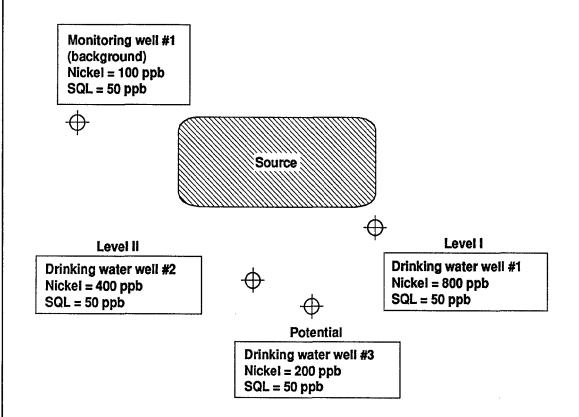
Highlight 7-25 illustrates wells with Level I, Level II, and potential contamination.

ESTABLISHING ACTUAL CONTAMINATION

The steps outlined below describe how to establish actual contamination based on chemical analysis for a single hazardous substance. Actual contamination based on direct observation is not discussed. These steps explain how to meet the observed release criteria at a target well and should be repeated for other hazardous substances to establish actual contamination for each individual hazardous substance, or to establish Level I contamination based on several hazardous substances using the I or J index. The data needed to establish actual contamination are summarized in *Highlight 7-26*.

- (1) Compile analytical results that indicate that a hazardous substance has been detected in a drinking water well. Results that show hazardous substances in monitoring wells cannot be used to document actual contamination, except for possible use as a background in establishing the observed release.
- (2) **Determine the background level for the hazardous substance.** Determining the appropriate background level requires analytical results from an appropriate background well for substances that could be naturally occurring, ubiquitous, or attributable to other sources in the areas. A background level of 0 can be assumed for substances that are neither naturally occurring, ubiquitous, nor attributable to other sources in the areas (i.e., a background sample may not be needed). See Chapter 5 for information on determining the appropriate background level for comparison with a drinking water well sample.
- (3) Determine whether the concentration of the hazardous substance is significantly above background. Detailed guidance for making this determination is found in Section 5.1, particularly *Highlight 5-2*.

HIGHLIGHT 7-25 EXAMPLES OF WELLS SUBJECT TO LEVEL I, LEVEL II, AND POTENTIAL CONTAMINATION



- Drinking water wells #1 and #2 are subject to actual contamination. The concentration of nickel is above the SQL (50 ppb) and greater than three times the background level (3 x 100 ppb = 300 ppb) at both wells. The ground water benchmark for nickel is 700 ppb.
 - Drinking water well #1 is subject to Level I contamination. The concentration of nickel (800 ppb) is higher than the benchmark of 700 ppb.
 - Drinking water well #2 is subject to Level II contamination. The concentration of nickel (400 ppb) is lower than the benchmark of 700 ppb.
- Drinking water well #3 is subject to potential contamination. The concentration of nickel (200 ppb) is above the SQL, but less than three times the background level.

HIGHLIGHT 7-26 DATA NEEDS FOR LEVEL OF CONTAMINATION

Actual Contamination

- Analytical results for drinking water wells
 - Concentrations of hazardous substances present in samples
 - Applicable DLs (i.e., SQL, CRQL, or DQ for hazardous substances in each sample.
- Background concentrations and applicable DLs of those hazardous substances detected in drinking water wells that are being used to document actual contamination
 - Should be comparable analytical results if hazardous substances could be naturally occurring, ubiquitous, or attributable to other sources in the area
 - If substances are not naturally occurring, not ubiquitous, and there are no other potential sources of that hazardous substance in the area, a background concentration of 0 can be assumed.

Level I or Level II

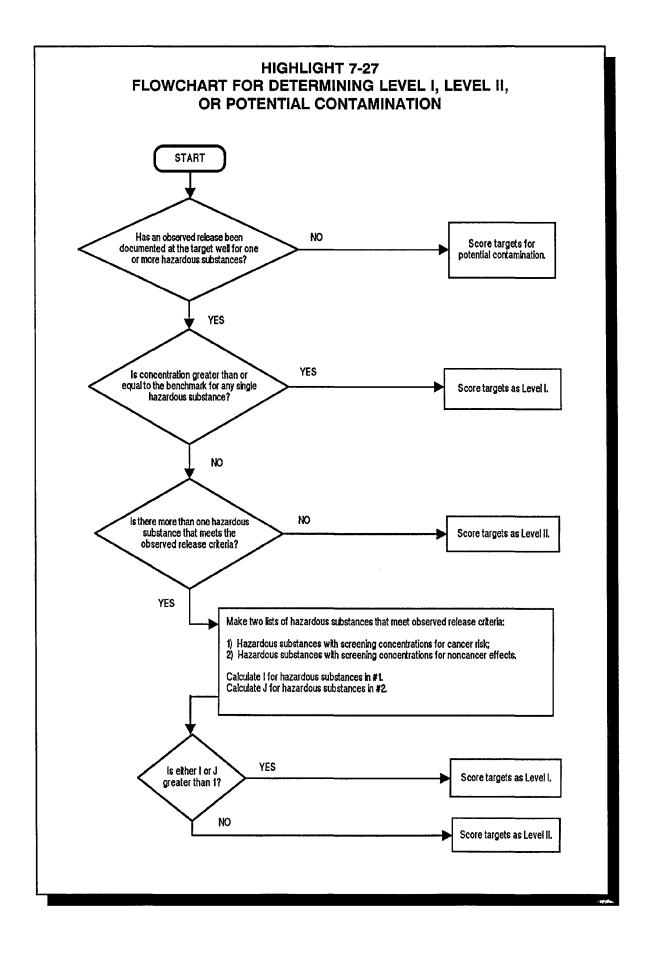
- Information listed above for actual contamination
- Health-based benchmarks for ground water for substances that meet observed release criteria (available in SCDM)
- (4) **Determine whether the hazardous substance can be attributed to the site.** Sampling results or records (e.g., manifests) indicating the presence of the hazardous substance in a source or sources at the site are the strongest documentation. Information that the hazardous substance was used at the facility also may be acceptable. See Chapter 5 for additional guidance on attribution, including attribution of degradation products.
- (5) Repeat this process for as many hazardous substances as feasible at the site.

DETERMINING LEVEL OF CONTAMINATION

The steps outlined below and in the flowchart in *Highlight 7-27* describe how to determine whether a target well should be scored as Level II, Level II, or potential contamination for an aquifer.

- (1) Determine which wells are target wells for the aquifer being evaluated and perform Steps (2) through (4) for each well.
- (2) Determine whether actual contamination can be established for any hazardous substance detected in the well. If actual contamination cannot be established (using the seven steps outlined above), score the well under potential contamination. If the well has not been sampled, score it under potential contamination, even if actual contamination has been established at downgradient wells. Note that if a well in an upper aquifer is subject to actual contamination and that well is also a target well for a lower aquifer, then that well is to be evaluated based on actual contamination when scoring the lower aquifer (see Section 7.9, Example 3).
- (3) Compare the concentration of each hazardous substance that meets the observed release criteria for the well with its applicable benchmark for the ground water pathway.

 Benchmarks are available in SCDM. If more than one benchmark applies (e.g., an MCL and a



screening concentration), then make the comparison only to the benchmark with the lowest concentration.

- If the concentration of any one or more of these hazardous substances is greater than or equal to its benchmark, score the well as Level I. Continue with the guidance provided in Section 7.5.
- If only one hazardous substance meets the observed release criteria and its concentration is less than its benchmark, score the well as Level II. Continue with the guidance provided in Section 7.5.
- If more than one hazardous substance meets the observed release criteria, but no single substance establishes Level I, continue to Step (4).
- (4) Calculate the I and J indices for all hazardous substances for this well that meet the observed release criteria. Make two lists of substances that meet the observed release criteria: hazardous substances with screening concentrations for cancer risk; and hazardous substances with screening concentrations for noncancer effects. Each hazardous substance may be on one, neither, or both of the lists. If more than one sample has been taken from a well and these samples are comparable (e.g., taken in the same time frame, collected using the same field techniques, analyzed by the same methods), for each hazardous substance, select the highest concentration to use in the calculations below.
 - Calculate the I index for all hazardous substances with screening concentrations for cancer risk that meet the observed release criteria, using the following equation:

$$I = \sum_{i=1}^{n} \frac{C_i}{SC_i}$$

where: C_i = concentration of substance i in well;

SC_i = screening concentration for cancer risk, which is the concentration corresponding to 10⁶ individual cancer risk for oral exposure for hazardous substance i; and

 number of hazardous substances that meet observed release criteria and for which an SC is available.

• Calculate the J index for all hazardous substances with screening concentrations for noncancer effects that meet the observed release criteria, using the following equation:

$$J = \sum_{j=1}^{m} \frac{C_j}{CR_j}$$

where: C_i = concentration of substance j in well;

CR_j = screening concentration for noncancer effects, which is the concentration corresponding to the reference dose for oral exposure for hazardous substance i; and

m = number of hazardous substances (1) that meet observed release criteria and (2) for which a CR is available.

• If either the I or J index is greater than or equal to 1, score the well as Level I. If both the I and J indices are less than one, score the well at Level II. An example of calculating the I and J indices is presented in *Highlight 7-28*.

HIGHLIGHT 7-28 CALCULATING I AND J INDICES

A well contains chemicals in the concentrations listed below. While no one of the chemicals alone was found in a concentration that would place the well in Level I, consideration of the chemicals in combination places the well in this category. When the I and J indices are calculated, the value for I is greater than 1 (i.e., 1.4) and the well is scored as Level I. This is true even though the J index is less than 1.

Chemical	Concentration C _i (mg/L)	Cancer Risk Screening Conentration SC _i (mg/L)	C _i /SC _i	ı
Х	4.7 x 10 ⁻⁴	6.3 x 10 ⁻⁴	0.75	
Y	3.1 x 10 ⁻⁴	4.2 x 10 ⁻³	0.074	1.36
Z	1.5 x 10 ⁻⁴	2.8 x 10 ⁻⁴	0.54	

Chemical	Concentration C _j (mg/L)	Reference Dose Screening Concentration CR _j (mg/L)	C _/ /CR _j	J
Х	4.7 x 10 ⁻⁴	1.6 x 10 ⁻¹	0.0029	
Υ	3.1 x 10 ⁻⁴	6.7 x 10 ⁻¹	0.00046	0.0039
Z	1.5 x 10 ⁻⁴	2.8 x 10 ⁻¹	0.00054	

SCORING SITES WITH ACTUAL CONTAMINATION

The determination of level of contamination is necessary to score the nearest well and population factors. In addition, establishing actual contamination may affect the minimum value for the hazardous waste quantity factor. *Highlight 7-29* summarizes the differences in scoring among wells subject to Level I Level II, or potential contamination. Detailed instructions for scoring nearest well and population factors for wells subject to actual contamination are provided in Section 7.5.

Highlight 7-30 illustrates scoring for Level I, Level II, and potential targets.

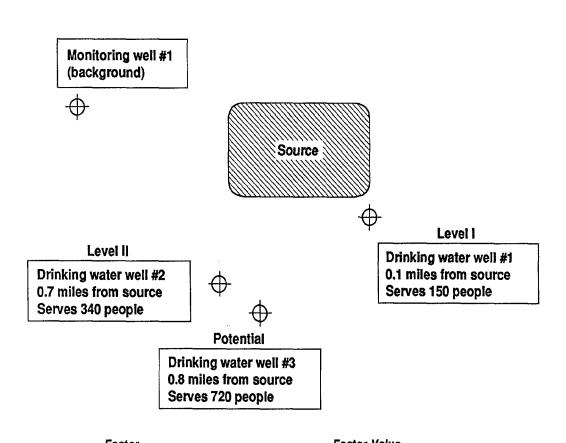
HIGHLIGHT 7-29 COMPARISON OF SCORING LEVEL I, LEVEL II, AND POTENTIAL CONTAMINATION

Level of Contamination	Nearest Well Factor Value	Population Factor Value	Minimum HWQ Factor Value ^a
Actual – Level I	50	10 x number of people	100
Actual – Level II	45	1 x number of people	100
Potential	0 to 20 – depends on distance to nearest drinking water well and presence of karst	0.1 x distance- weighted population	10 ^b

^a Minimum hazardous waste quantity factor values apply if Tier A is not adequately determined for all sources.

^b May be 100 in certain cases when there has been a removal action; see HRS section 2.4.2.2 and EPA's removal policy fact sheet.

HIGHLIGHT 7-30 SCORING GROUND WATER POPULATION SUBJECT TO LEVEL I, LEVEL II, AND POTENTIAL CONTAMINATION



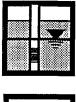
Factor				Facto	or value
Level I:	150	x	10	=	1,500
Level II:	340	Х	1	=	340
Potential ^a :	167	x	0.1	=	17
Population fac	ctor:			=	1,857

^a Because the wells are not in a karst aquifer, use the "other than karst" portion of HRS Table 3-12 to determine the distance-weighted population value. For a drinking water well 0.8 miles from the source, serving 720 people, the distance-weighted population value is 167.

TIPS AND REMINDERS

- Actual contamination cannot occur without an observed release, but an observed release does
 not necessarily establish actual contamination. Hazardous substances detected in drinking water
 wells or monitoring wells may be used to document a release; however, only hazardous
 substances in drinking water wells may be used to document actual contamination.
- Documenting actual contamination in a municipal well (or other wells serving multiple families)
 will generally result in a large number of targets points. Documenting one municipal well subject
 to actual contamination may provide a score greater than the cutoff. Consider sampling these
 types of wells if there is a possibility that they may be contaminated.
- If there is no Level I contamination, documenting actual contamination (Level II) in a single residential well results in 45 targets points for the nearest well factor plus one point for each person served by that well. Unless contamination is at Level I, actual contamination in additional residential wells may result in only a moderate number of additional targets points (i.e., one point per person served) and requires considerable effort and expense.
- Actual contamination <u>cannot</u> be inferred, even for wells that are within the TDL and between groups of contaminated wells.
- Former drinking water wells that have been abandoned can be scored based on actual contamination if (1) analytical data indicate an observed release at the wells when they were in use, and (2) the wells were closed because of site-related contamination.
- Assuming a maximum value for waste characteristics, for a site to score greater than or equal to the cutoff on the basis of actual contamination:
 - At least four people must be exposed at Level I contamination, assuming no Level II or potential populations;
 - At least 41 people must be exposed at Level II contamination, assuming no Level I or potential populations; or
 - Various combinations of populations may be exposed, such as two people exposed at Level I and 16 people exposed at Level II.
- Assign a minimum hazardous waste quantity factor value of 100 for the ground water pathway if a drinking water well is actually contaminated for any aquifer (not just the one being evaluated) and Tier A is not adequately determined for all sources.
- If wells in an upper aquifer that are subject to actual contamination are also target wells for a lower (non-interconnected) aquifer, then these wells still are evaluated based on actual contamination when scoring the lower aquifer. The likelihood of release value, however, is based on the lower aquifer (see Section 7.9, Example 3).
- In determining Level I contamination, if multiple benchmarks (e.g., an MCL and a cancer risk screening concentration) apply to a hazardous substance, use the benchmark with the lowest concentration in making the comparison.

SECTION 7.5 POPULATION AND NEAREST WELL FACTORS





The population factor in the ground water pathway evaluates the number of residents, students, and workers served by ground water wells (in the aquifer being evaluated and appropriate overlying aquifers) located within the TDL. The nearest well factor evaluates the threat to the maximally exposed individual and takes into account whether that individual is subject to actual or potential contamination. This section explains how to estimate the population (i.e., residents, students, and workers) that regularly uses ground water from wells within the TDL, how to score the ground water population factor, and how to score the nearest well factor.

The ground water population is the people served by wells located within the TDL, not the <u>residents living within the TDL</u> (see *Highlight 7-31*). People living within the TDL may obtain drinking water from wells outside the TDL or from surface water sources, and people living outside the TDL may obtain drinking water from wells located within the TDL.

RELEVANT HRS SECTIONS

Section 3.0.1 General considerations
Section 3.0.1.1 Target distance limit
Section 3.3.1 Nearest well
Section 3.3.2 Population

DEFINITIONS

Nearest Well Factor: Factor for evaluating the maximally exposed well. This factor is based on the presence of actual contamination or, for aquifers where no drinking water well is subject to actual contamination, the presence of karst and distance to nearest drinking water well.

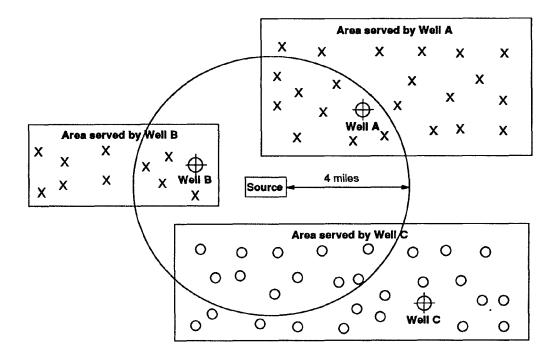
Population for the Ground Water Pathway: Number of residents, students, and workers regularly served by wells that are located within the TDL for the aquifer being evaluated (and appropriate overlying aquifers). This population does not include transient populations, such as hotel and restaurant patrons, but may include seasonal populations (e.g., a resort area).

Students: Full- or part-time attendees of an educational institution or day care that is served by a well located within the TDL.

Target Distance Categories: Concentric rings (not necessarily circular) with radii 1/4, 1/2, 1, 2, 3, and 4 miles from the sources at the site. These distance categories are used to group the wells subject to potential contamination for distance weighting.

Target Distance Limit for the Ground Water Migration Pathway: The distance over which targets are evaluated. The TDL is generally a 4-mile radius from sources at the site, except:

HIGHLIGHT 7-31 IDENTIFYING TARGET AND NON-TARGET RESIDENCES



X indicates a residence served by a target well
O indicates a residence served by a non-target well

All persons living in residences served by Wells A and B are included in estimating the ground water population. Because Well C is outside the TDL, persons served by Well C are <u>not</u> included in the ground water population.

NOTE: The situation above is presented for illustration purposes only. Typically, water from wells in a municipal system is blended together and distributed to residences in the municipal system. That is, a single municipal well generally does not serve a particular group of residences. Guidance on scoring blended water supplies is provided in Section 7.6.

- Include any drinking water well with an observed release attributed to the site, regardless
 of its distance from the source.
- Exclude wells completed in portions of an aquifer that are beyond an aquifer discontinuity (see Section 7.1).

Target Wells for Aquifer Being Evaluated: Wells that are located within the TDL, and drawing water from the aquifer being evaluated <u>or</u> an overlying aquifer through which hazardous substances would migrate.

Workers: Permanent employees (part-time or full-time) of a facility or business that is served by a well located within the TDL.

EVALUATING THE GROUND WATER POPULATION FACTOR

The steps below describe an approach to estimating the population served by target wells for the aquifer being evaluated. First, contact water authorities that have wells within the TDL to determine or estimate the population served by municipal water systems. (See *Highlight 7-32* for data needs that the water authority may be able to fulfill.) If the water authority provides an estimate of the population served by the system, use that number for your ground water target calculations. The water authority should know if the population served includes workers and/or students in addition to residents. If the population estimate does not include workers and/or students, it may be possible to modify the following methodology. The assumptions used should be clearly presented in the documentation record.

If the water authority provides just the total number of connections, then estimate the population served by multiplying the number of connections by the county average number of persons per household. After making an initial estimate of residential population served, estimate any student and worker populations served by the municipal system, and adjust the total. Next, evaluate residential populations served by private wells within the TDL. At each stage, evaluate whether documenting additional population will be important to the site score.

Depending on site circumstances, the scorer may conduct these steps in a different order. For example, if many people within the TDL use private wells or if private wells are subject to actual contamination, it may be more efficient to consider residential populations served by private wells before considering student or worker populations served by municipal connections.

- (1) **Draw target distance categories.** Draw concentric rings with radii 1/4, 1/2, 1, 2, 3, and 4 miles on a topographic map from the edges of the source. If there is an aquifer discontinuity, exclude any areas beyond the discontinuity. Remember that any well with a documented observed release attributable to the site is evaluated regardless of its distance from sources.
- (2) Identity all municipal systems with target wells for the aquifer being evaluated. Repeat Steps (3) through (5) for each system if more than one municipal system has wells within the TDL. If no municipal system has a well within the TDL, proceed to Step (7).
- (3) Identify all system water supply units In the aquifer being evaluated or an overlying aquifer. These units may include drinking water wells and standby wells. If the municipal system is a blended system, identify all wells inside and outside the TDL. Also identify all surface water intakes and standby intakes contributing to a blended system.
- (4) Evaluate the population served by the municipal water system, assuming all service connections are <u>residential</u>. Because connections to schools or businesses generally serve more individuals than those in a typical household, this assumption may result in a lower estimate of the target population. If this assumption yields a high score, however, time consuming inquiries to document student or worker populations may be avoided.

HIGHLIGHT 7-32 DATA NEEDS FOR GROUND WATER POPULATION

Obtain from Local, Municipal, or Other Water Authorities:

- Location of all municipal wells within the TDL and the aquifer(s) in which each is completed
- Number of persons reserved or service connections for each well that is not part of a blended system
 - If number of persons is provided, determine if number includes students and/or workers
 - If number of service connections is provided, obtain any available information about breakdown for connections to residences, schools, and businesses
- For wells in a blended system:
 - Total number of wells and intakes in the system (including those outside the TDL)
 - Total population served or number of service connections
 - Whether any well of intake provides more that 40 percent of the system's water
 - Average annual pumpage or capacity for each well (only needed if the water authority states that one well provides note that 40 percent of the system's water, or if the percent contribution of each well to the system needs to be determined by calculation)
- Delineation of areas within the TDL served by municipal water system

Obtain from Local Health Department, Water Commission, or Other Entity:

- Delineation of areas within the TDL not connected to the municipal system
- Information on where residents in these areas obtain water

Obtain from U.S. Bureau of Census Reports:

 Average number of persons per residence for each county served by target wells in the aquifer being evaluated.

Obtain from Business and Schools:

- Information on how they obtain water
- Number of workers and/or students

- Locate target municipal wells. Mark all municipal wells located within the TDL and completed in the aquifer being evaluated (or an overlying aquifer) on the map.
- Estimate population served by municipal wells, assuming all residential connections.
 - Independent systems. If a single well serves a particular group of residences and is not blended with water from other wells or surface water intakes, determine the number of service connections for that well. Multiply the number of connections by the county average number of persons per residence from, for example, U.S. Bureau of Census reports.
 - Blended systems. If the wells are part of a blended system, obtain information about the entire system in order to apportion the total population served to each well or intake. The necessary data include:
 - total number of people served or service connections for the blended system;
 - -- number of wells inside the TDL;
 - -- number of wells outside the TDL;
 - number of surface water intakes in the system;
 - whether any individual well or intake provides more than 40 percent of the water to the system; and
 - -- whether any wells or intakes are standby wells or intakes.

If any one well or intake provides more than 40 percent of the water to the system, collect data on the annual average pumpage or capacity for each well or intake (see Section 7.6, which provides additional information on apportioning population in blended systems). Multiply the number of service connections assigned to each well within the TDL by the average number of persons per residence.

- Identify any municipal wells subject to Level I or Level II concentrations for the aquifer being evaluated. (See Section 7.4.) Keep a separate count of persons served by wells contaminated at Level I or Level II; do <u>not</u> count them in the population subject to potential contamination for that aquifer. Tabulate data on number of persons served by level of contamination and, for wells subject to potential contamination, by karst/non-karst and target distance category.
- (12) Calculate a population factor value, assuming all residential connections. *Highlight 7-33* illustrates tabulating populations and calculating the population factor value.
 - Multiply the total number of individuals served by wells subject to Level I concentrations by 10.
 - Multiply the total number of individuals served by wells subject to Level II concentrations by 1.
 - Use HRS Table 3-12 to assign a distance-weighted population value for karst and nonkarst for populations served by wells subject to potential contamination. For each target distance category, sum the karst and non-karst distance-weighted population values. Multiply the total distance-weighted population value by 1/10.

HIGHLIGHT 7-33 DOCUMENT GROUND WATER POPULATION FOR AN AQUIFER ^a

Level I Concentrations				
Level I Well	Population (individuals)		Reference ^b	
W-1		4	32,10, 11	
	L	evel I Concentrations Fa	ctor Value: 1 x 4 =40	
	Level II Co	ncentrations		
Level II Well	Populatio	on (individuals)	Reference ^b	
W-2		3	32, 10, 12,	
W-3		4	32, 10, 13	
Level II Concentration Factor Value: 1 x [3 + 4] = 7				
	Potential C	ontamination		
Distance Category (miles)	Population (individuals)	Distance-weighted Population Value (other than karst)	Reference ^b	
0 to 1/4	None	0		
>1/4 to 1/2	None	0		
>1/2 to 1	3241	1669	30, 25, 18	
>1 to 2	3241	939	30, 25, 18	
>2 to 3	8052	678	31, 25, 18	
>3 to 4	None	0		

Potential Contamination Factor Value: $1/10 \times [1669 + 939 + 678] = 329$

Total Population Factor Value: 40 + 70 + 329 = 376

^a The document should identify in which aquifer the well being evaluated is screened. All wells in this example are assumed to be screened in the same aquifer. If wells were completed in more than one aquifer, add a column to the table that identifies the aquifer.

^b The numbers in the reference column would identify particular references in the HRS scoring package.

- Sum the values calculated for Level I, Level II, and potential contamination to obtain the population factor value (for municipal wells, assuming residential connections only).
- (6) **Determine if documenting student or worker populations Is cost effective**. If it is, continue to Step (7). If not, proceed to Step (9). In making this decision, consider:
 - Ground water pathway score assuming all residential connections. If the ground water
 pathway scores well over 100 by assuming all residential connections, it may not be
 cost-effective to document the student or worker populations. However, note the
 presence of student or worker populations using wells within the TDL in the
 documentation record.
 - Position within ranges for determining distance-weighted population. If the population served by municipal wells located in a particular target distance category is in the lower part or middle of a broad range (HRS Table 3-12), documenting students and workers may not change the population factor value. However, if the population served by municipal wells is near the upper end of a range, a substantially higher population factor value might be achieved by documenting the students and workers. If the population is at the lower end of a range, evaluating the student or worker population may help solidify the score.

(7) Document student and/or worker populations.

- Identify schools and businesses served by wells within the TDL. Obtain information from
 water authorities on schools and businesses served by the municipal system. Identify
 schools or businesses within the TDL that do not use municipal water (and thus may
 have a private well).
 - Document any schools or businesses served by wells subject to actual contamination.
 - For potential contamination, focus efforts generally on large schools (e.g., universities) or schools and businesses that are supplied by wells in the closer target distance categories.
 - For any newly identified private well, document that it is completed in the aquifer being evaluated or an overlying aquifer.
- Document the number of students or workers for those schools or businesses identified.
 - Contact the school officials to document student population.
 - Contact the business in question to document worker population, or refer to business census data.
- (8) Calculate a population factor value that Includes the student/worker populations. Follow the procedure outlined in Step (5) above. Be sure to subtract any service connections to schools or businesses from the total number of service connections (i.e., no longer assume all service connections are residential).
- (9) Evaluate population served by private/community wells within the TDL.
 - Delineate areas served by municipal and private/community wells.

- Municipal wells. Some areas may be served by water systems with no wells within the TDL. Mark these areas on a topographic map(s). Generally exclude these areas from the evaluation of private/community wells.
- Private/community wells. If some areas within the TDL are not supplied by a
 municipal water system, determine if they use private/ community wells
 (completed in the aquifer being evaluated or an overlying aquifer). Sources of
 this information include local agencies such as: water authority, public health
 department, or water commission. It may be helpful to mark areas that rely on
 private or community wells on a map.
- Estimate population served by private/community wells. Refer to the areas served by private/community wells (perhaps using the reference map). Use the most accurate information available to document this population. Computerized census data for small areas (e.g., block-by-block) are likely to be most accurate. If such data are not available, count the number of houses within these areas for each target distance category as indicated on a topographic map and multiply this number by the county average number of persons per residence. If the USGS map is outdated due to recent population growth (e.g., a new residential development), consider supplementing this house count using land use maps, aerial photographs, field counts, or other methods.
- (10) Revise the tabulation of ground water population from Step (5). Add the number of persons served by private wells to the appropriate category based on level of contamination and, for wells subject to potential contamination, karst/non-karst and target distance category. Use this revised tabulation to calculate a new population factor value.
- (11) Calculate a population factor value that Includes populations served by private wells. Follow the procedure outlined in Step (5) above.

Highlight 7-34 provides an example of scoring the ground water population factor.

EVALUATING THE NEAREST WELL FACTOR

In evaluating the nearest well factor, consider all target drinking water wells for the aquifer being evaluated used by residents, students, or workers. Do not consider wells other than drinking water wells, nor wells used exclusively by transient populations.

- (1) Determine If any drinking water well Is scored based on actual contamination for the aquifer being evaluated. If not, continue to Step (2). If so, score the nearest well factor as follows:
 - If any target drinking water well is subject to Level I concentrations, assign a factor value of 50.
 - If any target drinking water well is subject to Level II concentrations, but no well is subject to Level I concentrations, assign a factor value of 45.
- (2) Determine If any target drinking water well for the aquifer being evaluated Is In a karst aquifer that underlies any portion of the sources at the site. If not, continue to Step (3). If so, assign a nearest well factor value of 20.
- (3) Determine the shortest distance to any target drinking water well for the aquifer being evaluated from any source at the site with a ground water containment factor value greater than 0. Use HRS Table 3-11 to assign a nearest well factor value based on this distance.

HIGHLIGHT 7-34 SCORING EXAMPLE OF GROUND WATER POPULATION FACTOR

Water Supply: Blended municipal system consisting of 12 wells. No single well or intake supplies

more than 40 percent of the system's water.

Location of Water Supply:

Two of the municipal wells are located within the TDL;

W-A in the >1/2 -1 mile category, and

W-B in the >1 - 2 mile category.

Neither well is subject to actual contamination. Both wells are completed in the aquifer being evaluated, which is non-karst.

Evaluation:

The total number of service connections for the municipal system is 69,840. The entire area served by the municipal system lies within one county. 1990 census data indicate that the average number of persons per residence for that county is 2.8. <u>Assuming all connections are residential</u>, the total population served by the system is:

69,840 X 2.8 = 195,552

Because no single well supplies more than 40 percent of the blended system's water, the scorer apportions the population equally to all 12 wells (see section 7.6 for guidance on evaluating blended systems):

W-A: (1/12) X (195,552) = 16,296 persons

W-A: (1/12) X (195,552) = 16,296 persons

Use HRS Table 3-12 to assign distance-weighted population values to each well for the aquifer.

Potential Contamination			
Distance Category (miles)	Population (individuals)	Distance-weighted Population Value (other than karst)	
0 to 1/4	None	0	
>1/4 to 1/2	None	0	
1/2 to 1	16,296	5,224	
>1 to 2	16,296	2,939	
>2 to 3	None	0	
>3 to 4	None	0	
Potential Contamination Factor Value: 1/10 x [5,224 + 2,939] = 816			

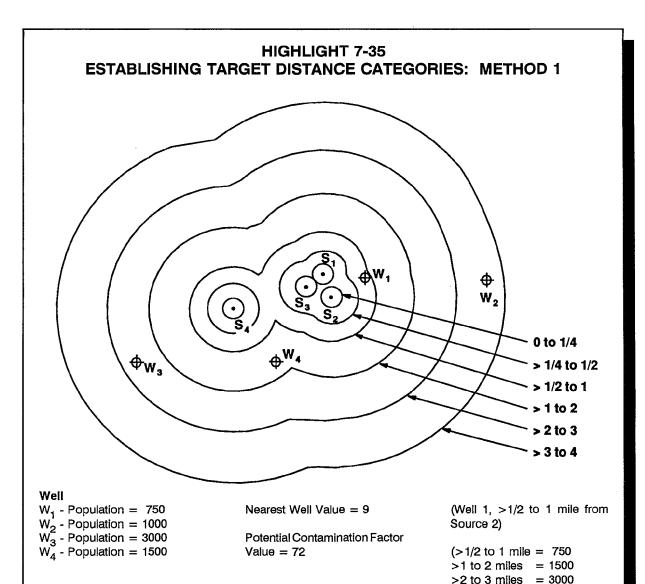
Because no well is subject to actual contamination:

Population Factor Value = 816

EVALUATING GROUND WATER PATHWAY WHEN MULTIPLE SOURCES ARE PRESENT

This section presents two methods that may be used to evaluate the potential contamination and nearest well factors when multiple sources are present at a site.

- In the first method (see *Highlight 7-35*), draw distance categories independently around every source, determine aggregate distance categories (e.g., make overlapping rings of the same distance category), and total the population subject to potential contamination from drinking water wells for each distance category. The total populations for each distance category are then used to determine the potential contamination factor value. Individuals are counted only once (except when an individual is a resident and a student or worker), in the distance category for the well nearest to a source and used by the individual. The distance to the nearest well is the shortest distance from any source with ground water containment greater than 0 to any target drinking water well for the aquifer being evaluated. At sites with a large number of sources, this method may be time-consuming and inefficient. Because factor values are assigned based on population range within distance categories, a simplified method may be used with little or no impact on the pathway score.
- (3) In this method (see *Highlight 7-36*), the nearest well is measured from any eligible source (i.e., as in the first method). However, rather than calculate the population subject to potential contamination for all sources, the scorer determines which source or sources will give the most representative score for the site based on distances to wells from each source and populations served by each well. Distance categories are drawn only for this source (or sources). This method is most effective for sites with a large number of sources and for sites with large populations using wells within the TDL. Note, however, that this method may underestimate target scores.

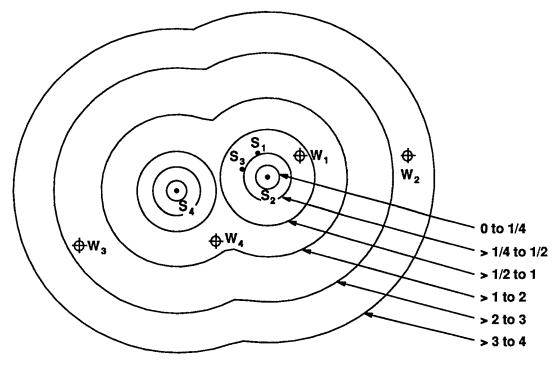


- Measure the nearest well distance from the nearest source.
- Draw distance categories around every source, and then determine aggregate distance categories.
- Sum the population subject to potential contamination assigned to wells within each specified distance category to determine the total population for each distance category (e.g., sum the populations subject to potential contamination for >1 to 2 mile distance for all sources to get a total potential contamination population value for the >1 to 2 mile distance category).
- Count individuals only once (except when an individual is a worker, student, and/or resident). Assign
 each target well to the distance category nearest to a source (e.g., Well 4 in this diagram would be
 counted only in the 1 to 2 mile distance category for Source 4 and would not be counted for other
 sources).
- This method may be unwieldy and time-consuming for sites with many sources. For such sites, a simplified method (method 2) may be followed with little or no impact on the overall site score.

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>3 to 4 miles = 1000)

HIGHLIGHT 7-36 ESTABLISHING TARGET DISTANCE CATEGORIES: METHOD 2



Well

 W_1 - Population = 750

 W_2 - Population = 1000 W_3 - Population = 3000

 W_4 - Population = 1500

Nearest Well Value = 9

Potential Contamination Factor

Value = 72

(Well 1, >1/2 to 1 mile from Source 2)

(>1/2 to 1 mile = 750)

>1 to 2 miles = 1500 >2 to 3 miles = 3000 >3 to 4 miles = 1000)

- Measure the nearest well distance from the nearest source.
- Determine which well or wells may give the most representative score for the site based on distances to wells from each source and populations served by each well.
- Draw distance categories around only those sources significantly affecting the potential contamination factor.
- In this example, the nearest well is calculated from Source 2 and the population subject to potential contamination could be calculated from Sources 2 and 4 because Sources 1 and 3 would not contribute significantly to the total population score (compare with *Highlight 7-35*).
- This method may simplify scoring efforts at sites with many sources or dense populations, with little or no impact on the overall score. However, in some instances, it may underestimate the ground water population factor value.

TIPS AND REMINDERS

- Determine if individuals are within the TDL by the location of their well, not the location of their residence, school, or workplace.
- If a maximum score for the ground water pathway can be reached by evaluating only municipal wells, it may not be necessary to include the population served by private wells in the scoring. If people in the area use private wells, note this fact in the documentation record. One exception is that any well subject to Level I concentrations should be evaluated.
- Remember that the distance-weighted population values for potential contamination are assigned based on population <u>ranges</u>. Documenting a few private wells subject to potential contamination will result in a different population factor value only if the original population estimate was at the higher end of the range.
- The nearest well factor may have a significant effect on pathway score; therefore, evaluate this
 factor as accurately as possible. The nearest well factor can be scored based only on drinking
 water wells.
- Include the population using wells that were closed because of site-related actual contamination in estimates of the ground water population. This population should reflect the number of people using the well at the time it was closed.
- If a drinking water system being evaluated includes portions of more than one county and the specific number of residences supplied in each county is known, use county-specific estimates of persons-per-residence. Otherwise, use the lowest persons-per-residence figure to estimate the entire population served.
- An individual may be counted as a resident and as a student or worker. If an individual lives and attends school at locations served by drinking water wells within the TDL, count that individual as a resident and as a student.
- Well logs obtained from local drillers are a good data source for determining in which aquifer(s) private wells are completed. In areas with a large number of private wells, one way of documenting how many wells are completed in each of two aquifers is to obtain a representative sample of well logs and assume the same ratio for all private wells in the area.

SECTION 7.6 BLENDED WATER SUPPLIES





The population factor for the ground water pathway is evaluated based on level of contamination (i.e., Level I, Level II, and potential contamination) and on the locations of the ground water wells that supply people with drinking water. In some instances, discrete populations can be linked directly to individual water wells. In other cases, water from multiple wells and/or surface water intakes is blended prior to or during distribution to a target population. This section provides guidance on evaluating the population factor in the ground water pathway when water from multiple wells, or wells and surface water intakes, is blended prior to or during distribution.

In general, the HRS provides for dividing a target population among all the water supplies that contribute to a blended distribution system in either of the following two ways:

- If no supply unit contributes more than 40 percent (based on average annual pumpage or capacity) of the total supply, divide population equally among all the units.
- If any one supply unit provides more than 40 percent, estimate the percentage contribution of each unit and assign each a percentage of the population based on its relative contribution.

RELEVANT HRS SECTION

Section 3.3.2 Population

DEFINITIONS

Blended Water Distribution System: A drinking water supply system that can or does combine (e.g., via connecting valves) water from more than one well or surface water intake, or from a combination of wells and intakes.

Capacity: The amount of water a well or intake can deliver to a water distribution system. Capacity may be expressed in units that are equivalent to a pumpage rate or as a percentage of the system's requirements.

Pumpage Data: A measure of the volume of water per unit of time discharged from a well, or collected within an intake, either by pumping or free flow. Well pumpage is commonly measured in gallons per minute (gpm), cubic meters per day (m³/day; 1 gpm = 5.45 M³/day), or cubic feet per second (cfs; 1 gpm = 0.0023 cfs). Pumpage data may also be termed well production data, well discharge data, well flow data, well yield data, pumping line data, and for intakes, intake pipe flow data. For HRS purposes, pumpage data relate to the measured or estimated rate of water withdrawal from a well or intake, not from a storage tank or reservoir used as a receptor for water drawn from one or more wells and/or intakes. See **Highlight 7-37** for more information on pumpage data.

HIGHLIGHT 7-37 PUMPAGE AND CAPACITY DATA

A water authority may provide data on the contribution of each well or intake to the total blended water system In several forms, including pumpage, capacity, or specific capacity. All data used to apportion population must be of the same type (e.g., do not use capacity data for some wells or intakes and pumpage data for others) and in the same units. An abbreviated conversion table is provided below.

1 gal/min	= 0.00223 ft ³ /sec	= 5.45 m ³ /day
1 ft ³ /sec	= 448.8 gal min	= 2,447 m ³ /day
1 m ³ /day	= 4.09 X 10 ⁻⁴ ft ³ /sec	= 0.183 gal/min

Pumpage. Many water authorities keep pumpage records expressed as the total quantity of water pumped in a given interval, usually a day, a month, or a year, not in terms of pumpage for the period during which a well is used. Metered pumpage data are the most reliable. However, estimates of pumpage calculated by the water authority based on engineering parameters built into the well or intake design, construction, and pump configuration may also be acceptable.

Capacity. The sum of the capacities may represent more than the total needs of the system. The relative capacity of each component, however, may be calculated by dividing the capacity of the component by the sum of the capacities of all the components. This normalization procedure means that the sum of the relative capacities of all the components in the system will total 100 percent.

Specific Capacity. Because it is difficult to derive an equivalent term for surface water intakes, specific capacity data should only be used when the blended water system is supplied exclusively by ground water wells and when the specific capacity data are available for all wells In the system. If necessary, convert the specific capacity data for multiple wells to uniform units, then calculate the percentage contribution of each well to the blended system.

Standby Wells. When using pumpage data for a standby ground water well, use average pumpage for the period during which the standby well is used rather than average annual pumpage (HRS section 3.3.2). See Section 7.7 for additional information.

Specific Capacity: An alternative term to capacity that is associated with acceptance testing of ground water wells. Specific capacity is reported as the rate at which water is discharged from a well per unit drawdown in the aquifer in which the well is completed. This is usually expressed in gallons per minute per foot of drawdown (gpm/ft) or cubic meters per day per meter of drawdown (m³/d/m). The latter term may appear in the technical literature as m²/d.

Standby Well: A well held in reserve by a water supply entity (e.g., agency, authority, cooperative, private company, or individual) and maintained for use. It is designated as a drinking water supply well for use during a water supply shortage or emergency such as pump failure, drought, sudden water quality deterioration, or interruption in the regular supply. Additional terms commonly used to signify standby wells include reserve wells, drought wells, safety wells, emergency wells, backup wells, substitute wells, and uncommitted wells.

SCORING THE POPULATION FACTOR FOR BLENDED WATER SUPPLIES

The steps below outline the procedure for evaluating the population factor for blended water supplies, *Highlight 7-38* summarizes the data needed.

HIGHLIGHT 7-38 DATA NEEDFOR EVALUATING BLENDED SYSTEMS

The typical data needed to evaluate the population factor when blended water systems are involved can include all of the following:

- Identification of all the water supply entities potentially affected by site activities
- Number and location of water supply units (i.e., ground water wells, surface water intakes, standby/emergency supplies).
- Well completion data for those wells identified as water supply units.
 - Aguifer used
 - Screened interval
 - Water use
 - Well owner
- Specifics of the water distribution system
 - Geographic extent
 - Number and types of connections (residential, industrial, commercial)
- Pumpage and/or capacity data for wells and intakes expressed in comparable units.

Much of the information required to evaluate blended water systems can be collected directly from the water supply entities or local regulatory authorities. Inaddition, because some of the required information relates specifically to water resources studies, the district office of the Water Resources Division of the U.S. Geological Survey and its state counterpart should be contacted as necessary. These governmental units can provide more detailed well and flow data through such publications as their Water Resources Investigation series, the Hydrologic Atlas series, and annual reports on specific river basins.

- (1) Identify all blended water supply systems that may have wells within the TDL. If there is more than one blended system, repeat the following steps for each system. If a blended system supplies water to another blended system or receives water from another blended system, refer to the subsection below, Scoring Multiple Blended Systems.
- (2) Identify <u>all</u> water supply units for the blended system. The units may include ground water wells, surface water intakes, and standby/emergency supplies. Obtain this information from the water supply entity and mark the location of each supply unit on a topographic map. Information on surface water intakes and wells that are not within the TDL or not in the aquifer being evaluated is needed to correctly apportion the population served.
- (3) Determine which wells to evaluate as targets for the population factor.
 - Include as targets only wells that are within the TDL. Remember that any well subject to actual contamination is evaluated regardless of its distance from sources.
 - Include as targets only wells that are completed in the aquifer being evaluated (or an overlying aquifer).
 - If the blended system includes standby wells, see Section 7.7 for more detailed guidance on evaluating standby wells. Include or exclude some, all, or none of the standby well(s) to obtain the highest population factor. Exclude all standby surface water intakes.

- (4) **Determine the total number of persons served by the blended system.** Obtain this information from the water supply entity. If the data are provided in terms of service connections rather than persons served, multiply the number of service connections by the average number of persons per residence for the county. For more details on this evaluation, see Section 7.5.
- (5) Determine whether any single well or intake supplies more than 40 percent of the system's water. Obtain this information from the water supply entity, if possible.
- (6) Apportion the population in the blended system as follows:
 - If no single well or intake supplies more than 40 percent of the system's water, apportion the population <u>equally</u> to all wells and intakes in the system (i.e., divide the total population by the number of wells and intakes).
 - If a single well or intake supplies more than 40 percent of the system's water, apportion population to each well or intake <u>based on the percentage of water it supplies</u>. Use average annual pumpage or capacity (see *Highlight 7-39*) to determine the percentage of water each well or intake supplies.
- (7) Tabulate the population assigned to target wells for the aquifer being evaluated by:
 - Actual (Level I or II) or potential contamination
 - Karst and non-karst (for wells subject only to potential contamination)
 - Target distance categories (for wells subject only to potential contamination).

Highlights 7-39 and 7-40 illustrate scoring the population factor for blended systems.

SCORING MULTIPLE BLENDED SYSTEMS

Some blended water systems receive water from (or supply water to) another blended water system via one or more water mains. The steps below describe how to apportion population to each supply well or intake in such cases. The blended system that supplies water is referred to as System S; the blended system that receives water is referred to as System R. Note that if two or more blended systems provide water to each other, evaluate both as just one combined blended system; do not use the steps below.

APPORTION POPULATION SERVED BY RECEIVING SYSTEM (SYSTEM R)

- (1) **Determine population served by System R.** This step is identical to that for a normal blended system. Do <u>not</u> include the population served by the supplying system in the total.
- (2) **Identify all water supply units for System R.** The units are wells in System R, surface water intakes in System R, and water mains from the supplying system. Treat each water main in the same manner as one well or intake.
- (3) Determine whether any single System R water supply unit provides more than 40 percent of System R's total water. Note that the mains from System S are considered in this determination.
- (4) Apportion the population in System R as follows:
 - If <u>no</u> water supply unit supplies more than 40 percent of the system's water, apportion the population equally to each water supply unit in System R.

HIGHLIGHT 7-39 SCORING EXAMPLE OF SINGLE BLENDED SYSTEM WITH WELLS OUTSIDE THE TARGET DISTANCE LIMIT

Site Setting: A mixed-use suburban community.

Water Supply: Single ground water authority with one water treatment plant. Seven wells (all

completed in the aquifer being evaluated) supply water to the treatment plant prior to

distribution.

Location of Water Supply

One well between 1/2 and 1 mile of the site

- One well between 2 and 3 miles of the site
- Two wells between 3 and 4 miles of the site
- Three wells in a well field 5 miles from the site

The water authority reports 100,000 residential connections.

Population

Served: The population density in the county in which the site is located is 2.5 persons per

residence. Assuming all residential connections:

Population served = $100,000 \times 2.5 = 250,000$ people

Evaluation: No Level I or Level II contamination is identified. Evaluate population based on

potential contamination. The water authority reports no well contributes more than 40 percent to the system. Therefore, assign 35,714.3 people (250,000/7) to each well in

the system (do not round at this point).

Distance-weighted population values (non-karst) are:

 Between 1/2 and 1 mile (one well: 35,714 people)
 16,684

 Between 2 and 3 miles (one well: 35,714 people)
 6,778

 Between 3 and 4 miles (two wells: 71,428 people)
 4,171

 Beyond 4 miles (three wells: 107,143 people)
 N/A

Potential contamination factor value = $1/10 \times 27,633 = 2,763$

Population factor value = 2,763

HIGHLIGHT 7-40 SCORING EXAMPLE FOR TWO SEPARATE BLENDED SYSTEMS

Site Setting: A densely populated urban center.

Water Supply: Two water authorities (Systems A and B) with separate water treatment plants and separate distribution systems. All wells are completed in the aguifer being evaluated.

- System A is supplied by four ground water wells.
- System B is supplied by five ground water wells.

Location of

Water Supplies: System A:

- One well between 1 and 2 miles of the site
- One well between 2 and 3 miles of the site
- Two wells between 3 and 4 miles of the site

System B:

- Two wells between 3 and 4 miles of the site
- Three wells more than 4 miles from the site

Population Served:

The population density in the county served by the water systems is 2.5 persons per residence.

Water Authority A reports 80,000 residential connections.

Population served by System A = $80,000 \times 2.5 = 200,000$ people

Water Authority B reports 20,000 residential connections.

Population served by System B = $20,000 \times 2.5 = 50,000$ people

Evaluation:

No Level I or Level II contamination is identified. Evaluate population based on potential contamination. Both water authorities report no wells contributing more than 40% of their total needs.

Assign 50,000 people (200,000/4) to each System A well.

Assign 10,000 people (50,000/5) to each System B well.

The distance-weighted population values (non-karst) are:

Between 1 and 2 miles (System A - 50,000)	9,385
Between 2 and 3 miles (System A - 50,000)	6,778
Between 3 and 4 miles (System A - 100,000; System B - 20,000)	13,060
Beyond 4 miles (System B - 30,000)	N/A

Potential contamination factor value = $1/10 \times 29,223 = 2,922$

Population factor value = 2,922

- If a water supply unit supplies more than 40 percent of the system's water, apportion population to each water supply unit <u>based on the percentage of water it supplies</u>. Use average annual pumpage or capacity to determine the percentage of water supplied by each well, intake, or main.
- (5) Apportion the population to the wells and intakes in System R, plus the mains from System S. Then, for System R determine which wells are within the TDL. Tabulate only the population served by System R wells. Do not include the population apportioned to mains from System S. In some cases, no System R wells will be within the TDL for the aquifer being evaluated. Even in these cases, population must be apportioned so that System S can be evaluated. As with all blended systems, the population is tabulated by level of contamination and, for wells subject to potential contamination, by karst/other than karst and target distance category.

APPORTION POPULATION SERVED BY THE SUPPLYING SYSTEM (SYSTEM S)

- (1) **Determine the total population served by System S**. This population includes all people served by System S plus some of the people served by System R.
 - Refer to Step (4) above for the number of people served by System R that were apportioned to each System S water main.
 - Add this number to the population served directly by System S to calculate the total population served by System S.

After calculating the total population served by System S, ignore the water mains for the rest of these steps.

- (2) **Identify all water supply units for System S**. The water supply units are ground water wells in System S and surface water intakes in System S. The water mains to System R are not water supply units for System S.
- (3) Determine whether any single System S well or intake supplies more than 40 percent of System S's water.
- (4) Apportion the population in System S as follows:
 - If <u>no</u> well or intake supplies more than 40 percent of the system's water, apportion the population <u>equally</u> to all wells and intakes in System S.
 - If a well or intake supplies more than 40 percent of the system's water, apportion population to each well or intake <u>based on the percentage of water it supplies</u>. Use average annual pumpage or capacity to determine the percentage of water each well or intake supplies.
- (5) Include the population apportioned to any System S well within the TDL in the tabulation of population served for the aquifer being evaluated. As with all blended systems, the population is tabulated by level of contamination and, for wells subject to potential contamination, by karst/non-karst and target distance category.

An example of apportioning population to two blended systems in which one is supplying water to the other is provided in *Highlight 7-41*.

HIGHLIGHT 7-41 SCORING EXAMPLE FOR MULTIPLE BLENDED SYSTEMS

Water Supply: System R: Blends water from four wells and receives water from System S via 2

water mains; no single well or main provides >40% of the system's

water.

System S: Blends water from eight wells; no well provides >40% of the system's

water.

Location of

Wells: System R: 2 wells > 1-2 miles from the site

2 wells > 2-3 miles from the site

System S: 2 wells > 3-4 miles from the site

Other 6 wells outside TDL

Population

Served: System R: 30,000 people

System S: 20,000 people

Evaluation: Apportion population served by receiving system - System R

Number of water supply units = 4 wells + 2 mains = 6 units

People/unit = 30,000/6 = 5,000

Assign 5,000 people to each System R well and to each water main from System S.ª

Apportion population served by supplying system - System S

Total Population = 20,000 (population served by System S) + 10,000 (population

apportioned to the two water mains supplying system R) =

30.000

Number of water supply units = 8 wells

People/unit = 30,000/8 = 3,750

Assign 3,750 people to each System S well.^a

Population

Factor: The distance-weighted population values (non-karst) are:

Potential contamination factor value = $1/10 \times 2,034 = 203$

^aNote that the total number of individuals allocated to wells is 50,000 (i.e., 5,000 for each System R well and 3,750 for each System S well). Although the total allocated is the same total as the population served (i.e., 20,000 plus 30,000), the population assigned to systemS wells is greater than that served by System S (i.e., 30,000 versus 20,000) while the population allocated to System R wells Is less than that served by System R (i.e., 20,000 versus 30,000).

TIPS AND REMINDERS

- If no single well or intake supplies more than 40 percent to the total blended system, apportion the population equally to all wells and intakes <u>even if more definitive information is available</u>. Equal apportionment simplifies the scoring process and provides a nationally consistent approach.
- Allocate population served to each well or intake in the blended system, but only include in the evaluation of the aquifer those populations that are allocated to wells located within the TDL.
- When two or more blended systems provide water to each other, evaluate both as one combined blended system.
- If some wells in a blended system are subject to actual contamination and some to potential contamination, first use the rule for apportioning population for a blended system to assign a population to each well. Then score the population assigned to each well based on whether Level I, Level II, or potential contamination applies to that well.

SECTION 7.7 STANDBY WELLS





This section defines standby wells and associated terms, provides guidance regarding the use of standby wells to evaluate certain targets factors in the ground water pathway, and explains how to apportion population to standby wells. If a standby well located within the TDL draws water from the aquifer being evaluated or from any overlying aquifer, the well may be used to evaluate both the nearest well and population factors. To designate a standby well as the nearest well, HRS section 3.3.1 states that it must be "used for drinking water supply at least once every year." A standby well can be used to evaluate the population factor when it is "maintained on a regular basis so that water can be withdrawn" (HRS section 3.3.2). Standby wells are not considered in the evaluation of the resources factor. *Highlight 7-42* summarizes the use of standby wells in evaluating targets.

RELEVANT HRS SECTIONS

Section 3.3.1 Nearest well Section 3.3.2 Population

DEFINITIONS

Annual Use: Criterion for determining whether a standby well may be used to evaluate the nearest well factor. To meet this criterion, a standby well generally should supply drinking water for at least one 24-hour period in a year.

Pumpage Data: A measure of the volume of water per unit of time discharged from a well, or collected within an intake, either by pumping or free flow. Well pumpage is commonly measured in gallons per minute (gpm), cubic meters per day (m³/day; 1 gpm = 5.45 m³/day), or cubic feet per second (cfs; 1 gpm = 0.0023 cfs). Pumpage data may also be termed well production data, well discharge data, well flow data, well yield data, pumping line data, and for intakes, intake pipe flow data. For HRS purposes, pumpage data relate to the measured or estimated rate of water withdrawal from a well or intake, not from a storage tank or reservoir used as a receptor for water drawn from one or more wells and/or intakes.

Regular Maintenance: The routine inspection, cleaning, and testing of a well so that it can be ready for immediate use. This is a criterion for determining whether a standby well may be used to evaluate the population factor. Regular maintenance of a standby well may include direct measurement of the static water level, inspection of the well and pump, and testing of the pump. Such activities generally should be conducted at least once a year, and the operating authority should consider the well functional. Rehabilitation activities, with the intent of retaining a standby well in a state of readiness, also can be considered regular maintenance. Such activities include pump cleaning and lubrication, screen and gravel pack cleaning, and treatment for encrustation and/or biofouling.

Specific Capacity: An alternative term to capacity that is associated with acceptance testing of ground water wells. Specific capacity is reported as the rate at which water is discharged

HIGHLIGHT 7-42 DATA NEEDS AND SOURCES FOR STANDBY WELLS

- Consider both the definition of standby well and the aquifer in which it is completed in identifying eligible standby wells.
- Document annual use when evaluating the nearest well factor.
- Document regular maintenance when evaluating the population factor.
- Do <u>not</u> consider when evaluating resources.
- Contact water supply entities (or regulatory authorities) directly to obtain the following data needed to evaluate standby wells:
 - Ensure that the well is one that is held in reserve to be used during a water supply emergency.
 - Confirm that the well is regularly maintained.
 - Obtain well logs or completion records that link the standby well to either the aquifer being evaluated or an overlying aquifer.
 - Additional information (e.g., pumpage or capacity data) may be required when apportioning populations to standby wells and then using the standby well to evaluate the population factor (See Section 7.7).

from a well per unit drawdown in the aquifer in which the well is completed. This is usually expressed in gallons per minute per foot of drawdown (gpm/ft) or cubic meters per day per meter of drawdown (m³/d/m). The latter term may appear in the technical literature as m² /d.

Standby Well: A well held in reserve by a water supply entity (e.g., agency, authority, cooperative, private company, or individual) and maintained for use. It is designated as a drinking water supply well for use during a water supply shortage or emergency such as pump failure, drought, sudden water quality deterioration, or interruption in the regular supply. Additional terms commonly used to signify standby wells include reserve wells, drought wells, safety wells, emergency wells, backup wells, substitute wells, and uncommitted wells.

Wellfield Rotation Program: Program in which wells within a water supply system are used only for specified intervals, Generally, a pattern is repeated until every supply well has been used, and then the entire cycle is repeated. Rotation programs are designed to minimize drawdown interference and to maximize efficient use of water in relation to varying water demand. Do not consider a well that is part of a planned wellfield rotation program a standby well.

SCORING THE NEAREST WELL FACTOR USING STANDBY WELLS

Follow the general steps given below to evaluate the nearest well factor based on a standby well.

(1) **Identify target standby wells.** The well must meet the definition of standby well and be within the TDL for the aquifer being evaluated. If the standby well is subject to actual contamination, it can be evaluated regardless of its distance from sources.

- (2) Determine whether a target standby well is eligible to be used to score the nearest well factor. The standby well can be used to score the nearest well factor if:
 - It is used to supply drinking water.
 - It has been used annually (as defined above). It is not necessary to document that the well has been used annually for the entire time it has been designated as a standby well. Documenting recent annual use (e.g., for the past five years) generally is sufficient. If the well was brought into a state of readiness only within the past few years, annual use since that time should be documented.
- (3) Use the eligible standby well as the nearest well if it results in a higher factor value score than any regular well. This could occur if the standby well is subject to actual contamination and the regular wells are not, or if the standby well is closer to the sources at a site (or possibly if the standby well is in a karst aquifer and the regular wells are not).

SCORING THE POPULATION FACTOR USING STANDBY WELLS

- (1) **Identify target standby wells**. The well must meet the definition of standby well and be within the TDL for the aquifer being evaluated. If the standby well is subject to actual contamination, it can be evaluated regardless of its distance from sources.
- (2) Determine whether a target standby well is eligible to be used to score the population factor. The standby well can be used to score the population factor if it:
 - Is used to supply drinking water
 - Has been regularly maintained (as defined above)
- (3) Calculate the population factor with and without the standby well.
 - If there is more than one eligible standby well, calculate the population factor value for various combinations of wells. Each combination must include:
 - All regular wells (and regular surface water intakes)
 - Some, all, or none of the standby wells (standby switches are not included)
 - None of the standby surface water intakes
 - Do <u>not</u> assign the same population to both a standby well and a regular well or surface water intake.
 - Use the average pumpage (e.g., gallons per minute) for the period during which the standby well is used (i.e., do not attempt to annualize pumpage data for standby wells as done for regular wells). If these data are not available, use capacity for all wells to calculate the population factor. *Highlight 7-43* provides additional information on pumpage and capacity data for standby wells.
- (5) Choose the combination of regular and standby wells that results in the highest population factor value for the aquifer being evaluated.

Highlight 7-44 provides an example of calculating average pumpage for a standby well. **Highlight 7-45** provides an example of scoring the population factor using a standby well.

HIGHLIGHT 7-43 PUMPAGE AND CAPACITY DATA FOR STANDBY WELLS

If no well or intake provides more than 40 percent of the total water supply for the system, simply apportion the population equally among the wells and/or intakes. However, if one well or intake does provide more than 40 percent of the total water supply, apportion the population according to each well's or intake's relative contribution to the total blended system. Consider the following points when apportioning population in a system with standby wells where one water source provides more than 40 percent of the total supply.

- (8) Use either capacity or pumpage data to calculate the percentage of the population to be assigned to each component of the system. Do not use pumpage data for one component and capacity data for other components. Data from standby wells and regular supply wells must be in the same units.
- (9) When using pumpage data for a standby well, use average pumpage for the period during which the standby well is used rather thanaverage annual pumpage. The period during which a standby well Is on line but not actually pumping should <u>not</u> be considered part of the period during which the standby well is used.
- (10) Often, pumpage data for standby wells are not based on water flow meter readings, but reflect estimates based on pumping test data, pump size, orifice of effluent pipe, or duration of pumping. Use metered pumpage data whenever possible; alternatively, estimate pumpage based on these or other appropriate parameters.
- (11) If possible, attempt to calculate an average over the most recent periods of use. However, calculation of the pumpage rate for a standby well can be based on a period of use several years ago.

HIGHLIGHT 7-44 USING PUMPAGE DATA FOR STANDBY WELLS

Standby Well

Use: Used for 28 days in a year.

60,480,000 gallons are pumped during the 28 days.

Calculation of

Pumpage: For evaluation purposes, calculate the pumpage rate for the standby well as follows:

60,480,000 gallons = 1,500 gpm (28 day)(24 hr/day)(60 min/hr)

Apportionment:

Water from this standby well is blended with water from three regular supply wells with pumpage rates of 2,000, 1,000, and 4,000 gpm. The largest contribution of any well is:

$$\frac{4,000}{1,500 + 2,000 + 1,000 + 4,000} = 0.47 = 47\%$$

Therefore, apportion population to the four wells based on each well's relative contribution. Note that if the standby well was not considered, the largest contribution would be 57 percent and apportionment to the three regular supply wells would still be based on relative contribution.

HIGHLIGHT 7-45 EVALUATING POPULATION FACTOR USING A STANDBY WELL

Site Setting: Rural location with low population density.

Water Supply: Local water authority blends water from one surface water intake (pumping 450 gpm), and one

well (pumping 550 gpm).

Another ground water well (capable of pumping at a rate of 550 gpm) is regularly maintained to

serve as an emergency supply.

Location of

Water Supply: Intake is located on a stream within 1/2 mile of PPE for the site.

Regular well is between 1/2 and 1 mile of the site.

Emergency well is between 1 and 2 miles of the site.

Population

Served: 1,000 residential connections.

Population density in the county is 2.4 persons per residence.

Total population served = $1,000 \times 2.4 = 2,400$

Evaluation: No Level I or Level II contamination is identified. Evaluate population served on the basis of

potential contamination. Water authority reports that the standby well can provide enough water

during any interruption in either the surface water or regular ground water supply.

Alternative 1: Include the standby well in apportioning population to the blended system.

The largest relative contribution by any well or intake is:

$$\frac{550}{(550 + 450 + 550)} = 35.5\%$$

Because none of the water supply units provides more than 40 percent of the total, assign one-third of the total population (800 people) to each well or intake.

The distance-weighted population values (non-karst) are:

Between 1/2 and 1 mile (800 people)	167
Between 1 and 2 miles (800 people)	. 94

Potential contamination factor value = $1/10 \times 261 = 26$

Do not evaluate the 800 people assigned to the surface water intake in the ground water pathway; they would be evaluated in the surface water pathway. In evaluating the surface water pathway, the standby well would not be included.

(continued on next page)

HIGHLIGHT 7-45 (continued) EVALUATING POPULATION FACTOR USING A STANDBY WELL

Alternative 2: Exclude the standby well in apportioning the population to the blended system.

The largest relative contribution to the blended system is provided by the ground water well:

550/(550 + 450) = 55%

Therefore, assign the total population to the two water units based on their relative percentage contribution:

Well = (2,400)(0.55) = 1,320 people Intake = (2,400)(0.45) = 1,080 people

The distance-weighted population values (non-karst) are:

Potential contamination factor value = $1/10 \times 523 = 52$

NOTE: The 1,080 people assigned to surface water intake are not evaluated for the ground

water pathway.

Selected

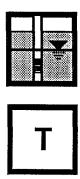
Alternative: Because Alternative 2 results in a higher potential contamination factor value, use it to

evaluate the aquifer.

TIPS AND REMINDERS

- (12) The annual use criterion applies only to the nearest well factor evaluation. A standby well can be used to evaluate the population factor without meeting the annual use criterion, providing it is regularly maintained so that water can be withdrawn.
- (13) Standby wells need not be evaluated; if they are, evaluate only those that raise the score. The apportioning of population using standby wells may differ for each aquifer evaluated (i.e., it is not necessary to consider an eligible standby well for one aquifer simply because it is considered for a different aquifer). Do not assign the same population to both a standby well and a regular well or intake when apportioning drinking water population,
- (14) Do not include standby surface water intakes when scoring the ground water pathway.
- (15) Wells that are part of a planned wellfield rotation program are not considered standby wells.
- (16) Any standby well used to determine relative contributions for a blended system should also be used in the apportionment of population.
- (17) Use average pumpage for the period of use, rather than average annual pumpage, when evaluating standby wells.

SECTION 7.8 RESOURCES AND WELLHEAD PROTECTION AREA



This section provides guidance on scoring the resources and wellhead protection area (WPA) factors for the targets factor category of the ground water pathway. The resources factor (HRS section 3.3.3) evaluates the possible loss of ground water use value resulting from site-related contamination. It does not evaluate threats to human health that are considered in the nearest well and population factors. The wellhead protection area factor (HRS section 3.3.4) evaluates the possibility that a source or observed release lies in or near an area that a state has designated for protection under the SDWA.

RELEVANT HRS SECTIONS

Section 3.3.3 Resources

Section 3.3.4 Wellhead protection area

DEFINITIONS

Commercial Aquaculture: Cultivation of fish or shellfish to be sold for widespread distribution. Examples include a rearing pond used to raise catfish or a pond for nonfood crops such as goldfish and tropical fish.

Commercial Food Crops: Crops that are intended to be sold widely, such as in supermarkets, and locally, such as those sold at local produce stands. Crops grown for domestic consumption or for use in a single restaurant are not considered commercial food crops.

Commercial Forage Crops: Crops grown to be sold as food for livestock (it is not necessary to document that these crops were sold only for commercial livestock), and grasslands used for grazing by commercial livestock (including areas technically defined as "pasture/rangeland" by the USDA).

Ingredient In Commercial Food Preparation: Ground water used for wholesale food preparation (e.g., a manufacturer that prepares food products to be sold in supermarkets or produce stands). Food prepared in restaurants is not included in this category.

Major or Designated Water Recreation Area: A major water recreation area is an area used by a large number of people for recreational purposes (e.g., a water theme park). A designated water recreation area is an area designated and maintained by a government body (e.g., local, state, or Federal) as an area for public recreation (e.g., municipal swimming pool).

Wellhead Protection Area (WPA): Area designated by states according to section 1428 of the SDWA, as amended, to protect wells and recharge areas that supply public drinking water systems.

SCORING THE RESOURCES FACTOR

- (1) Use the checklist In *Highlight 7-46* to determine whether any uses that are assigned resource points apply to any target well for the aquifer being evaluated. Standby wells cannot be used to score the resources factor. Use the definitions above to assist in making this determination. Because the resources factor receives an "all or nothing" value, it may not be necessary to continue with the other questions on the checklist after one resource use is identified. Note that the factor can be evaluated based on any target well in the aquifer being evaluated or in overlying aquifers. *Highlight 7-47* provides sources of information that may help document resource use.
- (2) If a resource use can be documented, assign a value of 5 to the resources factor for the aquifer. If no resource use can be documented, assign a value of 0.

SCORING THE WELLHEAD PROTECTION AREA FACTOR

WPAs are designated by state or local agencies; however, some states may not have any designated WPAs. Contact the state department of environmental protection or equivalent agency to determine the status of the state's WPA program and to obtain information on the location of WPAs.

- (1) **Determine whether there is a designated WPA within the TDL**. The WPA must be applicable to the aquifer being evaluated or an overlying aquifer through which hazardous substances would migrate to reach the aquifer being evaluated.
 - If not, assign a value of 0 to the WPA factor
 - If so, continue to Step (2).
- (2) Determine whether a source (with a ground water containment factor value greater than 0) lies either partially or fully above the designated WPA.
 - If so, assign a value of 20 to the WPA factor
 - If not, continue to Step (3).
- (3) Determine whether an observed release attributable to the sources at the site can be documented within the designated WPA.
 - If so, assign a value of 20 to the WPA factor
 - If not, assign a value of 5 to the WPA factor.

HIGHLIGHT 7-46 CHECKLIST FOR RESOURCES FACTOR

For the aquifer being evaluated:

(1)	Is ground water used to irrigate five or more acres of commercial food crops or commercial forage crops?	Yes	No
(2)	Is grouped water used to water commercial livestock?	Yes	No
(3)	Is ground water used as an ingredient in commercial food preparation?	Yes	No
(4)	Is ground water used as a supply for commercial acquaculture?	Yes	No
(5)	Is ground water used as supply or a major or designated water recreation area, other than for drinking water use?	Yes	No
(6)	If there are no drinking water wells within the TDL is ground water usable for drinking purposes?	Yes	No

If the answer is "yes" for any of the above possibilities, assign a resources factor value of 5. Otherwise, assign a resource factor value of 0.

HIGHLIGHT 7-47 INFORMATION SOURCES OF RESOURCE USE

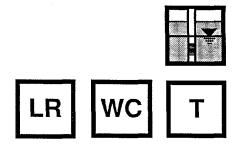
The following sources of information on possible ground water uses will help in documenting resource use for an aquifer:

- Topographical maps
- Field observations
- Well service records
- Interviews with water company officials
- Existing PA/SI reports
- Correspondence with nearby businesses
- Correspondence with other nearby entities, such as farms or universities
- Files from adjacent or nearby CERLIS sites
- USGS hydrogeologic investigation reports
- USGS's Ground Water Site Inventory (GWSI) data base
- The National Water Well Association's WELLFAX data base
- Agricultural extension agents
- Local Chambers of Commerce

TIPS AND REMINDERS

- A maximum of 5 targets points can be assigned for the resources factor. Do not spend a lot of time documenting resource use unless those 5 points may be critical to the site score.
- A well used for both drinking water and irrigation can be assigned targets points for the population, nearest well, and resources targets factors.
- Standby wells cannot be used to score the resources factor.
- Sole source aquifers do not qualify as WPAs unless they are so designated.
- Proposed WPAs should not be scored as WPAs; however, their proposed designation should be
 mentioned in the documentation record. If the proposed WPA is designated as a WPA before the
 scoring package goes final, the site score can be adjusted.

SECTION 7.9 SCORING SITES WITH MULTIPLE AQUIFERS



This section provides guidance on scoring the ground water pathway when multiple aquifers are present. A ground water pathway score is calculated for each aquifer at the site, and the highest score is selected as the ground water pathway score. When evaluating an aquifer, the HRS specifies that the targets using water from that aquifer are included as well as targets using water from all overlying aquifers through which hazardous substances would migrate to reach the aquifer being evaluated. This section provides several examples of scoring multiple aquifer systems.

RELEVANT HRS SECTIONS

Section 3.0 Section 3.1.2 Section 3.3 Section 3.3.1 Section 3.3.2 Section 3.3.2.4	Ground water migration pathway Potential to release Targets Nearest well Population Potential contamination
Section 3.4	Ground water migration score for an aquifer

DEFINITIONS

Multiple Aquifer System: A hydrogeologic situation consisting of two or more aquifers that are not interconnected and that underlie sources at the site.

SCORING MULTIPLE AQUIFER SYSTEMS

- (1) **Determine waste characteristics factor category value.** Calculate according to HRS section 3.2. Generally the waste characteristics factor category value will be the same for all aquifers evaluated for the site. However, it is possible for the mobility factor value to vary by aquifers (e.g., if there is an observed release to one aquifer but not others).
- (2) Determine likelihood of release factor category value for each of the aquifers being evaluated.
 - If an observed release to the aquifer being evaluated can be demonstrated based on direct observation or chemical analysis, assign that aquifer a likelihood of release factor value of 550.
 - If an observed release cannot be documented, score potential to release according to HRS section 3.1.2. Because several of the components of potential to release (depth to aquifer and travel time) are aquifer-specific, the potential to release factor value may be different for each of the aquifers being evaluated.

- (3) **Determine all targets for the shallowest aquifer being evaluated.** Document all targets for the shallowest aquifer, including the population, nearest well, resources, and WPAs.
- (4) Determine all targets for each deeper aquifer that Is evaluated at the site. Identify all targets in the deeper aquifer, plus those in any overlying aquifer through which hazardous substances would migrate to reach the aquifer being evaluated.
- (5) Calculate a separate ground water score for each aquifer.
- (6) Select the highest score from among the aquifers evaluated as the ground water pathway score for the site.

EXAMPLES OF MULTIPLE AQUIFER SYSTEMS

EXAMPLE 1: OVERLYING AQUIFERS EVALUATED UNDER POTENTIAL TO RELEASE (FIRST SCENARIO)

The site is located over two non-karst aquifers that are not interconnected. The shallower aquifer is designated Aquifer A and the deeper one is designated Aquifer B. Aquifer A lies 20 feet below the lowest known point of the hazardous substances at the site, and Aquifer B is approximately 85 feet below that same lowest known point. The same sources overly Aquifers A and B, and waste characteristics values are the same for both aquifers. The lowest hydraulic conductivity layer in the interval between the lowest known point of hazardous substances at the site and the top of Aquifer A is a 7-foot layer of silty clays. For Aquifer B, the lowest hydraulic conductivity layer is a 15-foot layer of clay.

Several private wells and one municipal well use Aquifer A, the nearest of which is 3/4 mile from the source. The only well that uses Aquifer B is 3.5 miles from the source, and serves a small trailer park community. There is no observed release to either aquifer. For both aquifers, the waste characteristics factor category value is 56, the containment factor value is 10, and the net precipitation factor value is 6.

Targets

Nearest Well. For Aquifer A, the nearest drinking water well from any source at the site is 3/4 mile. Assign it a nearest well factor value of 9 (from HRS Table 3-11). For Aquifer B, the nearest well factor may be based on the shortest distance from any source to a well in Aquifer B or Aquifer A. Because the nearest drinking water well in Aquifer B is 3.5 miles from the source, use the nearest well in Aquifer A to score Aquifer B's nearest well factor. Assign Aquifer B a nearest well factor value of 9.

Population. The following table presents the population served by drinking wells within the TDL for both aquifers. Because Aquifer A Is an overlying aquifer through which hazardous substances would migrate to reach Aquifer B, the entire population evaluated in Aquifer A is included in the evaluation of Aquifer B.

As specified in HRS section 3.3.2.4, multiply the total distance-weighted population by 1/10 to determine the value for the potential contamination factor. Therefore, the potential contamination factor is 69 for Aquifer A and 74 for Aquifer B.

Resources. No resource uses, as defined in HRS section 3.3.3, were documented for either aquifer.

Wellhead Protection Area. None were designated for either aquifer.

Distance Category	Evaluation of Aquifer A			Evaluation of Aquifer B (Wells in Overlying Aquifer A Included)		
(miles)	Wells	Population	Distance- weighted Population	Wells	Population	Distance- weighted Population
0 to 1/4	0	0	0	0	0	0
>1/4 to 1/2	0	0	0	0	0	0
>1/2 to 1	4	16	5	4	16	5
>1 to 2	12	48	10	12	48	10
>2 to 3	1	5,000	678	1	5,000	678
>3 to 4	0	0	0	1	320	42
Totals	1	5,064	693	-	5,384	735

Targets Factor Category Value. For each aquifer, this value is the sum of the four factors detailed above (population, nearest well, resource, wellhead protection area). Therefore, the targets factor category value is 78 for Aquifer A and 83 for Aquifer B.

Likelihood of Release

There is not an observed release to either aquifer, so potential to release is evaluated separately for each aquifer. Containment and net precipitation, two of the factor values used to determine potential to release, are the same for both aquifers and are equal to 10 and 6, respectively.

The other two factors, depth to aquifer and travel time, are different for Aquifers A and B. Because Aquifer A is 20 feet from the lowest known point of hazardous substances and Aquifer B is 85 feet from that point, assign Aquifer A and Aquifer B depth to aquifer factor values of 5 and 3, respectively. The geologic information provided indicates that Aquifer A should be assigned a travel time factor value of 15 and Aquifer B a value of 5 (see HRS Tables 3-6 and 3-7).

Calculate the likelihood of release factor category value by multiplying the containment factor value by the sum of the travel time, depth to aquifer, and net precipitation factor values. Based on this formula, Aquifer A has a likelihood of release factor category value of 260 (i.e., 10[15+5+6]) and Aquifer B has a likelihood of release category factor value of 140 (i.e., 10[5+3+6]).

Ground Water Pathway Score

As defined in HRS section 3.4, calculate a ground water score for each aquifer by multiplying the likelihood of release, waste characteristics, and targets factor category values and dividing the product by 82,500. The ground water score is 13.77 (i.e., [260 x 56 x 78]/82,500) for Aquifer A and 7.89 (i.e., [140 x 56 x 83]/82,500) for Aquifer B. Therefore, the score calculated for Aquifer A is used as the ground water pathway score for the site.

Although Aquifer B had a slightly higher targets value than Aquifer A, Aquifer B had a lower overall ground water score. This is because for this site the extra targets in Aquifer B did not contribute as much to the pathway score as the higher potential to release value (i.e., depth to aquifer and travel time factors) in Aquifer A.

EXAMPLE 2: OVERLYING AQUIFERS EVALUATED UNDER POTENTIAL TO RELEASE (SECOND SCENARIO)

The description of this site is the same as in Example 1, except that the drinking water well that uses Aquifer B is a municipal well that serves 15,000 people. This well is 3.5 miles from the source.

Targets

Nearest Well. The evaluation of the nearest well factor is performed as described in Example 1. For both Aquifers A and B, the nearest well factor is assigned a value of 9.

Population. The following table presents the population served by drinking water wells within the TDL for Aquifers A and B.

Distance	Evaluation of Aquifer A			Evaluation of Aquifer B (Wells in Overlying Aquifer A Included)		
Category (miles)	Wells	Population	Distance- weighted Population	Wells	Population	Distance- weighted Population
0 to 1/4	0	0	0	0	0	0
>1/4 to 1/2	0	0	0	0	0	0
>1/2 to 1	4	16	5	4	16	5
>1 to 2	12	48	10	12	48	10
>2 to 3	1	5,000	678	1	5,000	678
>3 to 4	0	0	0	1	15,000	1,306
Totals		5,064	693		20,064	1,999

As specified in HRS section 3.3.2.4, multiply the total distance-weighted population by 1 /10 to determine the value for the potential contamination factor. Therefore, the potential contamination factor is 69 for Aquifer A and 200 for Aquifer B.

Resources. No resource uses, as defined in HRS section 3.3.3, were documented for either aquifer.

Wellhead Protection Area. None were designated for either aquifer.

Targets Factor Category Value. For each aquifer, this value is the sum of the four factors detailed above (population, nearest well, resource, wellhead protection area). Therefore, the targets factor category value is 78 for Aquifer A and 209 for Aquifer B.

Likelihood of Release

The likelihood of release factor category values for Aquifers A and B are the same as in Example 1 - 260 for Aquifer A and 140 for Aquifer B.

Ground Water Pathway Score

As defined in the HRS section 3.4, a ground water score for each aquifer is calculated by multiplying the likelihood of release, waste characteristics, and targets factor category values and dividing the product by 82,500. The ground water score is 13.77 (i.e., [260 x 56 x 78]/82,500) for Aquifer A and 19.86 (i.e., [140 x 56 x 209]/82,500) for Aquifer B. Therefore, the score for Aquifer B is used as the ground water pathway score for the site.

In this example, the significantly larger targets value for Aquifer B compared with Aquifer A offsets the fact that Aquifer B has a lower likelihood of release value than Aquifer A.

EXAMPLE 3: ONE AQUIFER EVALUATED UNDER OBSERVED RELEASE AND ONE UNDER POTENTIAL TO RELEASE

Aquifer A lies above Aquifer B. An observed release by chemical analysis has been established to Aquifer A. One well, located 0.7 miles from the source, draws from Aquifer A, and it serves a family of five. Level I concentrations have been documented. There is no observed release to Aquifer B. Approximately 2.8 miles from the source, a municipal well serving 12,000 individuals uses Aquifer B. The waste characteristics factor category was assigned a value of 32 for both aquifers.

Targets

Nearest Well. Because Aquifer A is subject to Level I concentrations, assign it a nearest well factor value of 50 (see HRS section 3.3.1). The distance to the nearest well does not need to be taken into account.

The nearest well factor value for Aquifer B is also 50. Because hazardous substances would have to migrate through Aquifer A to reach Aquifer B, evaluate the nearest well factor for Aquifer B and any overlying aquifers (i.e., Aquifer A). The nearest well in Aquifer B is 2.8 miles from the source and would therefore be assigned a nearest well factor value of 3 (see HRS Table 3-11). Use 50, the higher of the two values, as Aquifer B's nearest well factor value.

Population. A single, private drinking well uses Aquifer A and serves a family of five. Because the well is subject to Level I concentrations, multiply the total population by 10. Therefore, the population factor value for Aquifer A is 50.

The municipal well 2.8 miles from the source that serves 12,000 people uses Aquifer B and is subject to potential contamination. According to HRS Table 3-12, assign a distance-weighted population value of 2,122. Multiply this value by 1/10 to obtain the potential contamination factor value of 212. Add to this the factor value of the Level I concentration population value of 50, which was calculated for Aquifer A. The total population factor value for Aquifer B is therefore 262.

Resources. No resource uses, as defined in HRS section 3.3.3, were documented for either aquifer.

Wellhead Protection Area. None were designated for either aquifer.

Targets Factor Category Value. For each aquifer, this value is the sum of the four factors detailed above (population, nearest well, resources, wellhead protection area). Therefore, the targets factor category is 100 for Aquifer A and 312 for Aquifer B.

Likelihood of Release

Because an observed release by chemical analysis was documented in Aquifer A, assign a likelihood of release value of 550. A potential to release value of 240 was calculated for Aquifer B, based on containment, net precipitation, depth to aquifer, and travel time factors.

Ground Water Pathway Score

As defined in the HRS section 3.4, calculate a ground water score for each aquifer by multiplying the likelihood of release, waste characteristics, and targets factor category values and dividing the product by 82,500. The ground water score is 21.33 (i.e., [550 x 32 x 100]/82,500) for Aquifer A and 29.04 (i.e., [240 x 32 x 312]/82,500) for Aquifer B. Therefore, the score calculated for Aquifer B is used as the ground water pathway score for the site.

TIPS AND REMINDERS

- The nearest well factor value can be based on either the aquifer being evaluated or an overlying aquifer through which hazardous substances would migrate.
- The population factor for a lower aquifer in a multiple aquifer system includes the population served by any overlying aquifer through which hazardous substances would migrate.